MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

Vol. L JANUARY-FEBRUARY, 1958 No. 1

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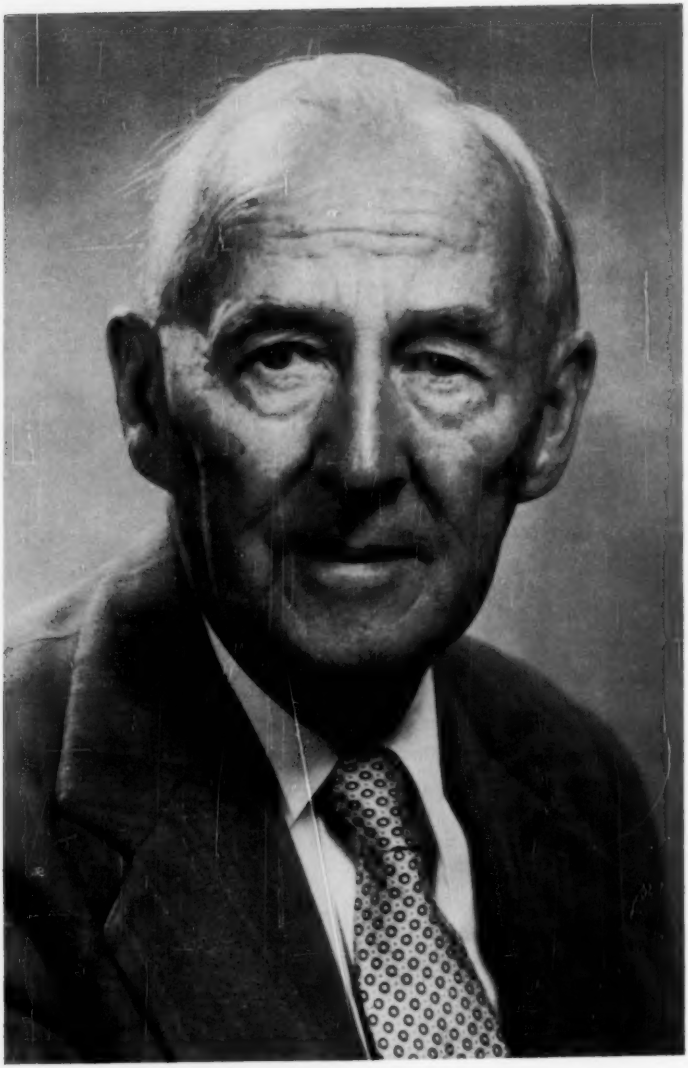

Ernst Athearn Bessey

MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. L JANUARY–FEBRUARY, 1958 No. 1

ERNST ATHEARN BESSEY

H. L. BARNETT[1]

(WITH PORTRAIT)

With the death of Dr. Ernst A. Bessey, at the age of 80 years, on July 17, 1957, the Mycological Society and the scientific world lost one of their best known and most capable mycologists. Dr. Bessey was also well known among scientists for his knowledge of languages and history, for his abilities as a teacher of the botanical sciences and for his many contributions to agriculture.

To pay adequate tribute to him and to give account of his activities and accomplishments during his long scientific career would require many pages. The following brief biographical sketch, however, would be in accord with Dr. Bessey's wishes and in line with his practice of writing.

Son of the eminent botanist Charles E. Bessey, Ernst Athearn Bessey was born February 20, 1877, at Ames, Iowa. In 1884 the family moved to Lincoln, Nebraska, where the elder Bessey was Professor of Botany at the University of Nebraska for many years. Ernst Bessey was graduated from high school in 1892. He then entered the University of Nebraska, where he received the following degrees: A.B., 1896; B.Sc.,

[1] The writer is indebted to Dr. E. S. Beneke, who collected much of the material upon which this sketch was written.

The photograph of Dr. Bessey, taken in 1954, was furnished by the Michigan State University Photographic Laboratory Information Service.

[MYCOLOGIA for November–December (49: 779–956) was issued March 28, 1958.]

1897; M.A., 1898; Honorary LL.D., 1946. He was elected to Phi Beta Kappa in 1896 and to Sigma Xi in 1898.

Following the custom of many young scientists of his time, he continued his graduate work in Germany, where he studied with Georg Klebs at the University of Halle and received the Ph.D. degree in 1904. During his stay in Europe he served as an agricultural explorer for the United States Department of Agriculture and in this service traveled in Russia, the Caucasus, Turkestan and Algeria. From these travels Dr. Bessey brought back offshoots of the date palm, which he subsequently showed capable of commercial production in this country.

In 1906 Dr. Bessey married Edith Carlton Higgins of Omaha, Nebraska. He spent two years in Washington, D. C., with the United States Department of Agriculture and was then appointed Director of the Subtropical Laboratory at Miami, Florida. He served as Professor of Botany at Louisiana State University at Baton Rouge from 1908 to 1910. In the fall of 1910 he went to the Michigan Agricultural College at East Lansing, where he spent the remainder of his brilliant career as Professor of Botany and Mycology and as Botanist in the Agricultural Experiment Station. From 1927 to 1930 he was given additional duties as Acting Dean of the Division of Applied Science, and from 1930 to 1944 he was Dean of the Graduate School, while continuing his duties as department head. During these years Dr. Bessey did much to build up the graduate school and to strengthen his department to the point where its leadership in plant pathological research was well recognized both here and abroad.

During the year 1939–1940 Dr. Bessey was Visiting Professor of Botany at the University of Hawaii, where much of his spare time was spent collecting fungi native to the islands. Upon his return to Michigan State College he brought with him more than 1000 specimens of Hawaiian fungi for study and identification. However, most of the taxonomic work had to wait until after he was relieved of active duty. Following his retirement in 1946, Dr. Bessey held the title of Distinguished Professor of Botany and Professor Emeritus. During recent years he spent considerable time working with other staff members of Michigan State University on the compilation of a dictionary of agriculture.

He was a member of several scientific societies and took an active part in their affairs. He was especially active in the Mycological Society of America, which he helped found and which he served as president in 1941. A listing of other professional societies to which he belonged

includes the American Association for the Advancement of Science, Botanical Society of America, American Phytopathological Society, Torrey Botanical Club, American Society of Naturalists, Deutsche Botanische Gesellschaft, and Michigan Academy of Science, of which he was president in 1915. He was a member of Phi Kappa Phi, Alpha Zeta and Phi Sigma. His was a starred name in the American Men of Science and included in Who's Who. An outstanding honor was bestowed upon Dr. Bessey in 1956, when he received a Certificate of Merit, awarded by the Botanical Society of America to botanists who had made outstanding contributions to the science. The citation read "Ernst Athearn Bessey, who with an undeviating zeal for accuracy has fashioned our generation's magisterial presentation of the science of Mycology."

During his scientific career Dr. Bessey was author of many articles in the fields of mycology, plant pathology, botany and agriculture. He was joint author with his father of the text *Essentials of Botany*, published in 1914. He wrote the first American textbook in mycology, published in 1935. This text was later revised and expanded, being published in 1950 as *Morphology and Taxonomy of Fungi*. This book is not only the most complete text available but serves a great need as a reference for those who seek an introduction to the taxonomic literature.

Dr. Bessey was deeply religious and was a staunch supporter of the church. His former students and associates will remember him as a man who took great interest in his students. In spite of his many other duties, he always took time to answer questions or to look at a fungus. For each graduate student under his supervision he set aside an hour each week for personal conference, and he became a valued personal friend of each.

Dr. Bessey emphasized detail and accuracy in his teaching and in his research. He firmly believed that scientific names should be pronounced as Latin, and according to the so-called Roman method, although in this he had few followers. His knowledge of fields related to mycology was a result of his keen memory for a wide array of scientific facts. Yet, when confronted with a genuine unknown, he would unhesitatingly admit "I don't know."

Having worked with Georg Klebs, it was natural that he should become interested in the aquatic Phycomycetes, but he found neither the opportunity nor the time to follow this interest to his satisfaction. Following the inclinations of his father, he was also a student of phylogeny, and he was convinced that the ascomycetes originated from the red algae.

In his discussions, however, he always presented the evidence for views opposed to his own. He freely pointed out to students and fellow mycologists where research was needed on perplexing problems.

The familiar figure of Dr. Bessey, the slight man with thinning white hair, squinting through a hand lens at a fungus collected on a mycological foray, or sitting near the front row at the Mycological Society meetings, will be missed for many years to come, but the memory of the enthusiasm with which he pursued his chosen scientific field will be an inspiration to all who knew him.

Dr. Bessey is survived by his widow, Edith Bessey, his sons William, Professor of Physics at Butler University, and Robert, Professor of Physics at the University of Wyoming, and four grandchildren.

SELECTED LIST OF MYCOLOGICAL PUBLICATIONS

Über die Bedingungen der Farbbildung bei Fusarium. 1904. Flora **93**: 301–334.

Dilophospora alopecuri. 1906. Jour. Mycol. **12**: 57–58.

Spore forms of *Spegazzinia ornata* Sacc. 1907. Jour. Mycol. **13**: 43–45.

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Isoplanogametes in *Blastocladia*. 1939. Mycologia **31**: 308–309.

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Notes on Hawaiian fungi. 1943. Papers Mich. Acad. Sci. Arts Lett. **28**: 3–8.

Aquatic Phycomycetes. 1943. Mycologia **35**: 582–584.

Studies upon *Galera crispa*. 1944. Papers Mich. Acad. Sci. Arts Lett. **29**: 9–14.

Studies on Pilobolus: *P. kleinii* and *P. longipes*. 1948. Papers Mich. Acad. Sci. Arts Lett. **32**: 15–26.

Morphology and taxonomy of fungi. 1950. Blaskiston, Philadelphia. XIII + 791 pp.

Notes on the genus *Camptomeris*, Fungi Imperfecti. 1953. Mycologia **45**: 364–390.

Mycology. *In* A century of progress in the natural sciences 1853–1953, pp. 225–265. Calif. Acad. Sci. 1955.

A new species of *Camptomeris*, and further notes on the genus. 1955. Papers Mich. Acad. Sci. Arts Lett. **40**: 3–8.

WEST VIRGINIA UNIVERSITY
MORGANTOWN

A SYNOPSIS OF THE UREDINALES WHICH PARASITIZE GRASSES OF THE GENERA STIPA AND NASELLA[1]

H. C. Greene and George B. Cummins[2]

(with 30 figures)

This paper presents a taxonomic treatment of the 25 species of the plant rust fungi which parasitize species of *Stipa* and *Nasella*. The majority of the species occur in the western areas of North and South America, seven are known in Europe and Asia, and a single species occurs in Australia.

Insofar as possible, type specimens were examined. There are only two species of which we have seen no certain representative collections. These are (1) *Uromyces stipinus* Tranz. & Eremeeva, of which we have had no material, and (2) *Uromyces ferganensis* Tranz. & Eremeeva, of which we have had a possible example. In the latter case, the teliospores agree well with those described but because Tranzschel and Eremeeva reported no detail regarding the telial sorus we cannot be certain that the specimen which we had is representative of their species.

The arrangement of the species, both in the keys and in the text, is in accordance with the group system proposed by Cummins (Plant Disease Reporter Supplement No. 237. 1956). Paraphysate species are known only in South America. Only two species, *Puccinia pazensis* H. C. Greene & Cumm. in South America and *Uromyces mussooriensis* Syd. in India, have verrucose urediospores. There are two species which

[1] Cooperative investigations between the University of Wisconsin, the Purdue University Agricultural Experiment Station, and the Plant Disease Epidemics and Identification Section, Agricultural Research Service, United States Department of Agriculture. Journal Paper No. 1133, of the Purdue University Agricultural Experiment Station.

[2] The Department of Botany, University of Wisconsin and the Department of Botany and Plant Pathology, Purdue University, respectively. The authors acknowledge with appreciation the loan of specimens by the Naturhistoriska Riksmuseet, Stockholm, Sweden and the National Fungus Collections, Washington, D. C. The junior author is indebted to Dr. J. R. Swallen for granting access to the grass collections of the U. S. National Herbarium. He also acknowledges the assistance of a Grant-in-Aid from the National Science Foundation which permitted field studies in the western United States.

are autoecious. They are *Puccinia graminella* Diet. & Holw. and *Uromyces pencanus* (Diet. & Neger) Arth. & Holw.

KEY TO THE SPECIES

PUCCINIA: teliospores 2-celled

GROUP II: Uredia with paraphyses; urediospores echinulate; pores scattered.
Teliospores without apical coronate projections.
Paraphyses straight, capitate, hyaline, wall uniformly 1 μ thick....1. *P. digna*
Paraphyses mostly straight, hyaline to yellow, capitate, wall 2.5–4 μ or more thick....2. *P. saltensis*
Urediospores mostly 16–20 × 18–25 μ; teliospores mostly 16–19 × 33–45 μ....var. *saltensis*
Urediospores mostly 21–25 × 24–29 μ; teliospores mostly 19–24 × 36–50 μ....var. *faldensis*
Paraphyses incurved, clavate, golden, wall 2.5–4 μ or more thick..3. *P. nasellae*
Teliospores with numerous apical coronate projections....4. *P. coronata*
GROUP V: Uredia without paraphyses; urediospores echinulate; pores equatorial.
Amphispores predominant, pores *mostly* equatorial....8. *P. substerilis* var. *oryzopsidis*
Amphispores none.
Teliospore pedicels exceeding 100 μ in length.
Teliospores oblong-ellipsoid, mostly 25–28 × 36–41 μ....5. *P. burnettii*
Teliospores ellipsoid, mostly 16–22 × 38–52 μ....6. *P. entrerriana*
Teliospore pedicels about 50 μ in length....7. *P. graminis*
GROUP VI: Uredia without paraphyses; urediospores echinulate; pores scattered.
Amphispores produced, usually predominant....8. *P. substerilis*
Amphispores mostly 25–30 μ long, wall mostly 3–3.5 μ, finely and closely echinulate....var. *substerilis*
Amphispores mostly 26–33 μ long, wall mostly 3.5–4 μ, coarsely and distantly echinulate....var. *scribneri*
Amphispores mostly 28–36 μ long, wall mostly 3.5–4.5 μ, coarsely and distantly echinulate, pores *equatorial* in *most* spores....var. *oryzopsidis*
Amphispores not produced; teliospores smooth.
Teliospores without apical coronate projections.
Teliospores mostly germinating without dormancy, mostly about golden brown; aecia systemic....9. *P. monoica*
Teliospores germinating only after dormancy, chestnut-brown; aecia localized if known.
Apical wall of teliospore mostly 6–10 μ, mostly rather narrowly rounded; pedicels typically exceeding 100 μ; urediospores brown.
Teliospores mostly 40–55 μ in length....10. *P. stipae*
Urediospores mostly 20–23 × 23–26 μ; teliospores mostly 20–25 × 45–53 μ....var. *stipae*
Urediospores mostly 18–21 × 21–23 μ; teliospores mostly 20–24 × 45–56 μ....var. *stipina*

Urediospores mostly 16–20 × 18–23 μ; teliospores mostly 18–23 × 36–50 μ.....var. *stipae-sibiricae*
Teliospores mostly 50–70 μ in length.....11. *P. lasiagrostis*
Apical wall of teliospores mostly 6–9 μ, obtuse or bluntly rounded; pedicels typically 25–40 μ; urediospores hyaline.....12. *P. mexicensis*
Apical wall of teliospores mostly 5–7 μ, broadly rounded; pedicels typically 50–85 μ in length; urediospores brownish.....13. *P. flavescens*
Teliospores commonly with apical coronate projections.....14. *P. neocoronata*
Amphispores not produced; teliospores verrucose.....15. *P. wolgensis*
GROUP VIII: Uredia without paraphyses; urediospores verrucose; pores scattered.....16. *P. pazensis*
GROUPS IX: Uredia not produced (or urediospores rarely seen).
Telia very large, usually 1 cm or more in length; heteroecious.
Teliospores verrucose, wall uniformly 8–10 μ thick.....15. *P. wolgensis*
Teliospores smooth, wall uniform or not more than 6 μ apically, spores less than 50 μ long.
Teliospore wall mostly uniformly 3–4 μ, pedicels fragile and broken short.....17. *P. avocensis*
Teliospore wall 2–3 μ at sides, 4–6 μ apically, pedicels persistent.....5. *P. burnettii*
Teliospores smooth, wall not uniform, exceeding 6 μ apically, spores typically exceeding 50 μ in length.....18. *P. intervenicns*
Telia small, usually 5 mm or less in length; autoecious, aecia usually associated with the telia.....19. *P. graminella*

UROMYCES: teliospores 1-celled

GROUP VI: Uredia without paraphyses; urediospores echinulate; pores scattered.
Urediospore wall hyaline, urediospores mostly 30–35 μ in length; aecia unknown.....20. *U. nasellae*
Urediospore wall golden to cinnamon, urediospores mostly less than 30 μ in length.
Teliospores mostly 21–25 × 27–34 μ, apical wall mostly 6–10 μ; aecia usually with the uredia and telia.....21. *U. pencanus*
Teliospores mostly 21–24 × 21–30 μ, apical wall mostly 4–7 μ; aecia unknown.....22. *U. fergauensis*
GROUP VII: Uredia without paraphyses; urediospores verrucose; pores equatorial.....23. *U. mussooriensis*
GROUP IX: Uredia unknown; teliospores 16–21 × 24–32 μ, apical thickening probably a pale differentiated umbo, attaining 11 μ in thickness, pedicels described as fragile.....24. *U. stipinus*

1. PUCCINIA DIGNA Arth. & Holw., in Arthur, Amer. Phil. Soc. Proc. **64**: 198. 1925 (FIG. 1).

Aecia unknown. Uredia epiphyllous, about cinnamon, pulverulent, with hyaline capitate paraphyses mostly 17–22 μ wide apically and 60–90 μ in length, the wall uniformly 1 μ thick; urediospores (21–)23–

28(–31) × (25–)27–32(–34) μ, mostly broadly ellipsoid or nearly globoid, wall (1–)1.5(–2) μ thick, cinnamon, echinulate, pores 5–8, scattered. Telia like the uredia except blackish and pulvinate; teliospores (18–)20–25(–28) × (33–)36–44(–50) μ, mostly oblong-ellipsoid, wall (1–)1.5–2(–3) μ thick at sides, 5–8(–10) μ apically, deep golden to chestnut; pedicels colorless, moderately thick-walled, usually not collapsing, attaining a length of 115 μ.

Hosts and distribution: *Nasella chilensis* (Trin.) Desv., *Stipa ichu* (Ruiz & Pav.) Kunth, *S. neesiana* Trin. & Rupr.: Bolivia and Chile.

Type: Holway No. 451 (Reliq. Holw. No. 71), on *Stipa ichu*, La Paz, Bolivia.

This species was described as being autoecious but we consider that the aecial collections belong to *P. graminella* or possibly to *P. saltensis*. Holway noted that two collections on *S. ichu* (Holway Nos. 362, 387, Reliq. Holw. Nos. 58, 64) were associated with his Nos. 363, 388 (*Aecidium poecilochromae* Jacks. & Holw.).

Arthur's figure 6, published as illustrating this species, actually is of the teliospores and one urediospore of *P. pazensis* H. C. Greene & Cumm. There are three collections (Holway Nos. 330, 342, Reliq. Holw. Nos. 50, 52 and Holway No. 389), which lack paraphyses. We consider that they are *P. stipae* Arth.

2. PUCCINIA SALTENSIS Cumm., Bull. Torrey Bot. Club **83**: 231. 1956, var. **saltensis** (FIG. 2).

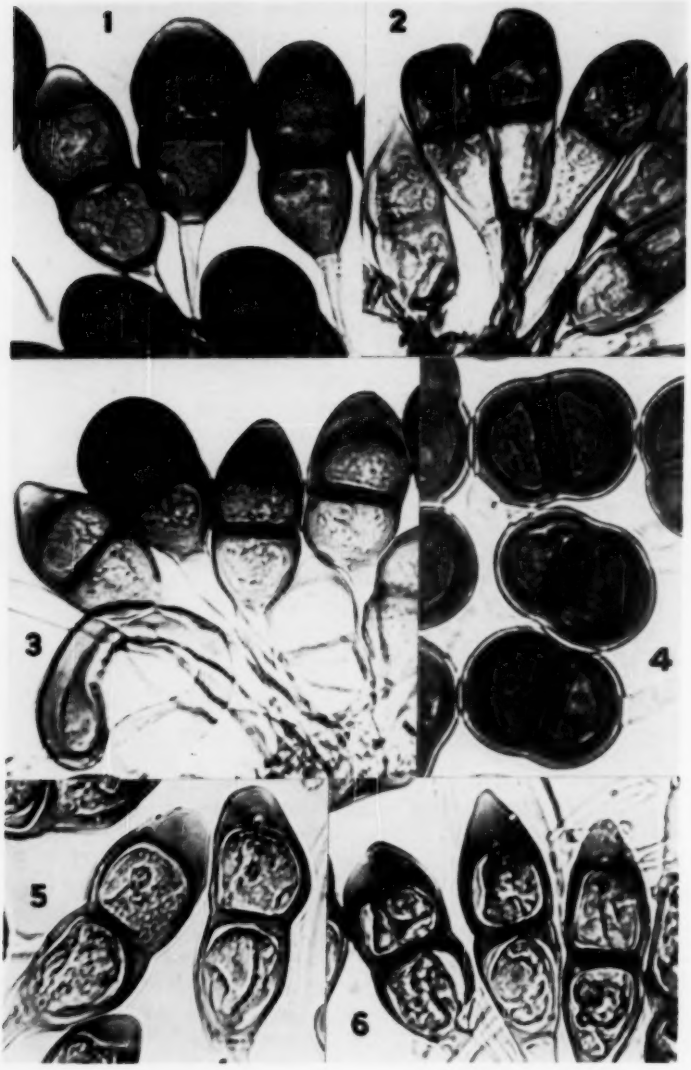
Aecia unknown. Uredia epiphyllous, cinnamon, pulverulent, with hyaline to golden paraphyses 13–16 μ wide apically and up to 90 μ in length, the wall more or less uniformly 2.5–4 μ thick; urediospores (15–)16–20(–22) × 18–25(–27) μ, mostly ellipsoid or broadly ellipsoid, wall 1.5–2(–2.5) μ thick, rather deep cinnamon, echinulate, pores 4–6, scattered. Telia epiphyllous, blackish, pulvinate; teliospores (14–)16–19(–22) × (30–)33–45(–50) μ, mostly clavate-ellipsoid or oblong-ellipsoid, wall chestnut, 1.5–2.5(–3) μ thick at sides, (5–)7–9(–11) μ apically, smooth; pedicels golden or yellowish, thin-walled and collapsing, attaining 55 μ in length.

Hosts and distribution: *Stipa ibarrensis* HBK., *S. tucumani* Parodi: Argentina and Ecuador.

Type: Hunziker No. 1844, on *S. tucumani*, Prov. Salta, Argentina.

The rust on *S. ibarrensis* (Holway No. 907, Reliq. Holw. No. 99) was published by Arthur as *P. digna*.

Collections which are generally similar but have larger urediospores and teliospores are segregated as var. *faldensis*.



FIGS. 1–6. Teliospores of *Puccinia*. 1. *P. digna* (from type). 2. *P. saltensis* var. *saltensis* (from type). 3. *P. nasellae* (from type); note incurved clavate paraphysis. 4. *P. burnettii* (from type). 5. *P. monoica* from type). 6. *P. monoica* (from *Oryzopsis hymenoides*, Colorado). All × 800.

PUCCINIA SALTENSIS var. **faldensis** var. nov. (FIG. 25).

Aeciis ignotis vel incertis; urediosporis (18–)21–25(–27)×(22–)24–29(–33)μ, plerumque late ellipsoideis, paraphysibus var. *saltensis* similibus; teliosporis (17–)19–24(–28)×(30–)36–50(–60)μ, clavatis vel clavato-ellipsoideis, membrana ad apicem 7–11(–15)μ cr., pedicello usque ad 85 μ longo.

Hosts and distribution: *Nasella chilensis* (Trin.) Desv., *N. flaccidula* Hack., *N. publiflora* (Trin. & Rupr.) Desv., *Stipa brachyphylla* Hitchc., *S. clarazii* Ball, *S. ichu* (Ruiz & Pav.) Kunth, *S. manicata* Desv., Argentina, Bolivia, Peru, and Uruguay.

Type: Holway No. 2026, on *Stipa ichu*, La Falda, Cordoba, Argentina.

Both the urediospores and the teliospores are larger than those of var. *saltensis;* the urediospores are more broadly ellipsoid, the apical wall of the teliospore tends to be thicker, and the pedicels are longer on the average. The type and Holway Nos. 449, 2039, 2044, and 2045 were published by Arthur, Amer. Phil. Soc. Proc. **64**: 198. 1925, as *P. digna*, which has uniformly thin-walled paraphyses, while Holway Nos. 418, 433, 497, 744, 2026a, and 2047 were published as *P. nasellae* Arth. & Holw., which has large clavate paraphyses and larger urediospores.

There are three collections (Holway Nos. 2039, 2044, 2045) from La Falda (the type locality) consisting of aecia and uredia which are often closely associated. The aecial peridial cells resemble those of *P. graminella* Diet. & Holw. and it is possible, despite the associated uredia, that the aecia belong to that species. It is also possible that *P. saltensis* var. *faldensis* may be autoecious.

3. PUCCINIA NASELLAE Arth. & Holw., in Arthur, Amer. Phil. Soc. Proc. **64**: 196. 1925 (FIG. 3).

Aecia unknown. Uredia epiphyllous, cinnamon, pulverulent, with abundant yellow or golden, strongly incurved, more or less uniformly thick-walled clavate paraphyses, mostly 10–15 μ wide apically and 65–115 μ in length, urediospores (19–)22–28(–30)×(23–)26–33(–36)μ, mostly broadly ellipsoid or nearly globoid, wall (1–)1.5(–2)μ thick, mostly golden, echinulate, pores (4?–)6–8(–10?), scattered, difficult to count. Telia like the uredia, including paraphyses, except blackish and pulvinate; teliospores (18–)20–23(–25)×(33–)36–44(–46)μ, mostly ellipsoid or clavate-ellipsoid, wall 1.5–2 μ thick at sides, (5–)7–10(–12)μ apically, chestnut, smooth; pedicels thin-walled, mostly collapsing, hyaline or yellowish, attaining a length of 75 μ.

Hosts and distribution: *Nasella caespitosa* Griseb., *N. chilensis* (Trin.) Desv., *Stipa* sp.: Argentina, Bolivia and Chile.

Type: Holway No. 508 (Reliq. Holw. No. 80), on *Nasella caespitosa*, Sorata, Bolivia.

The large, curved and clavate paraphyses which over-top the spore mass characterize this species. Paraphyses are developed in telia which arise *de novo* whereas in the other paraphysate species they appear to be present only in telia which have developed in old uredia.

Holway noted, in connection with the type collection, that aecia on *Desmodium* were associated with the rusted grass: "These found together many times." Jackson (Mycologia **23**: 344. 1931) referred these aecial collections to *Aecidium desmodii* P. Henn.

4. PUCCINIA CORONATA Cda. Icon. Fung. **1**: 6. 1837 (FIG. 26).

This common species is not described here. It appears to occur only rarely on species of *Stipa*. *P. coronata* (as *P. hierochloae* Ito) has been reported as occurring on *Stipa effusa* Nakai by Ito (Mycol. Flora Japan **2**(3): 156. 1950) and on *Stipa sibirica* Lam. by Tranzschel (Consp. Ured. U.R.S.S. 79. 1939). We have not seen this rust fungus on *Stipa* but we have examined the type specimen (FIG. 26) on *Hierochloë odorata* Beauv. It is typical of *P. coronata sensu lat.* in having very short teliospore pedicels and a "crown" consisting of numerous digitate projections which attain a length of 15 μ.

5. PUCCINIA BURNETTII Griff., Bull. Torrey Bot. Club **29**: 298. 1902 (FIG. 4).

Aecidium eurotiae Ell. & Ev., Jour. Mycol. **6**: 119. 1891.

Dicaeoma burnettii (Griff.) Arth. Rés. Sci. Congr. Bot. Vienne 344. 1906.

Dicaeoma eurotiae (Ell. & Ev.) Arth. & Fromme, N. Am. Flora **7**: 776. 1926.

Spermogonia hypophyllous. Aecia hypophyllous, fuscous, short-cylindrical or hemispherical, margin slightly or not lacerate; aeciospores (15–)17–22(–25) × (18–)21–25(–27) μ, globoid, broadly ellipsoid or oblong, wall (1.5–)2–2.5(–3.5) μ thick, pale yellowish, minutely verrucose. Uredia unknown; urediospores in the telia (20–)21–25(–30) × (24–)28–30(–34) μ, mostly broadly ellipsoid or broadly obovoid, wall 3–3.5 μ thick, yellow to golden, echinulate, pores 4 or 5, equatorial, obscure. Telia epiphyllous, chocolate, deeply pulvinate, fusiform and attaining a length of 2 cm; teliospores (22–)25–28(–31) × (32–)36–41(–47) μ, mostly oblong-ellipsoid, wall 2–3 μ thick at sides, 4–6 μ

apically, clear chestnut, smooth; pedicels colorless, moderately thick-walled but usually collapsing, attaining 200 μ or more in length but usually broken shorter.

Hosts and distribution: (aecial stage): *Eurotia ceratoides* C. A. Mey., *E. lanata* (Pursh) Moq.; (telial stage): *Oryzopsis hymenoides* (Roem. & Schult.) Ricker, *Stipa comata* Trin. & Rupr.: Wyoming to Washington, New Mexico, Nevada and in the U.S.S.R.

Type: Griffiths (West Am. Fungi No. 387), on *Stipa comata*, Buffalo, Wyoming.

The relationship of the aecial and telial stages was determined by E. Bethel as a result of field observations in Colorado and Wyoming. He believed the species to be obligately heteroecious.

P. burnettii is the only North American rust of *Stipa*, except *P. graminis*, which has urediospores with equatorial pores. The teliospores are more robust, thus shorter in relation to width, than other rusts of *Stipa*, excepting only the very distinct *P. wolgensis*.

6. PUCCINIA ENTRERRIANA Lindq., Bol. Soc. Argentina Bot. **5**: 157. 1954 (FIG. 12).

Aecia unknown. Uredia not seen; urediospores in the telia (16–)18–21 × (16–)20–24 μ, mostly ellipsoid or obovoid, wall 1.5–2 μ thick, cinnamon, echinulate, pores 3, equatorial. Telia epiphyllous, early exposed, deeply pulvinate, chocolate, linear to fusiform and attaining a length of 1 cm; teliospores (14–)16–22(–24) × (33–)38–52(–63) μ, ellipsoid or fusiform-ellipsoid, wall 1.5–2(–2.5) μ thick at sides, 4–10(–12) μ apically, golden to clear chestnut, smooth; pedicels hyaline or pale yellowish, rather thin-walled and usually collapsing, attaining a length of 150 μ but usually broken shorter; some of the spores appear to germinate without dormancy.

Hosts and distribution: *Stipa* sp.: Argentina.

Type: Hirschhorn (La Plata Museum No. 6100), Parera, Prov. Entre Rios.

The small urediospores, which appear to belong in the life cycle, the equatorial pores, and the small teliospores distinguish the species from *P. interveniens* Bethel to which it is otherwise similar. Even if, as pointed out following the description, *P. interveniens* may occasionally produce urediospores they have scattered pores. If the urediospores actually belong in the life cycle of *P. interveniens* the differing arrangement of the germ pores would indicate that the two species may not be as closely related as the similar teliospores might indicate.

7. PUCCINIA GRAMINIS Pers., Syn. Meth. Fung. 228. 1801.

This common species is not described here. It appears to occur only rarely on species of the genus *Stipa*. The only collections which we have seen are on *Stipa coronata* Thurb. from California.

8. PUCCINIA SUBSTERILIS Ell. & Ev., Bull. Torrey Bot. Club **22**: 58. 1895, var. **substerilis** (FIGS. 7, 8).

Uromyces scaber Ell. & Ev., Jour. Mycol. **6**: 119. 1891 (based on amphispores).

Puccinia scaber (Ell. & Ev.) Barth., N. Am. Ured. No. 2560. 1922.

Uredo luxurians Ell. & Ev., N. Am. Fungi No. 3583. 1898.

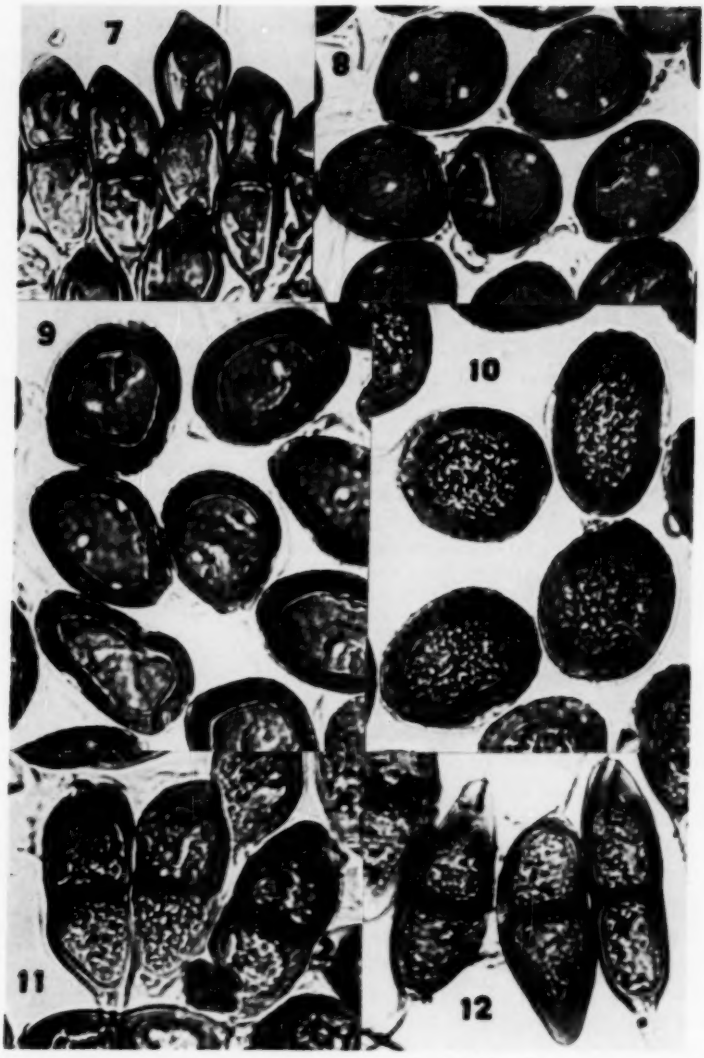
Dicaeoma scaber (Ell. & Ev.) Arth., Rés. Sci. Congr. Bot. Vienne 344. 1906.

Aecia unknown. Uredia epiphyllous, elliptical, yellowish brown, pulverulent; urediospores (16–)18–22(–25) × (20–)23–26(–30) μ, broadly ellipsoid or globoid, wall 1–2 μ thick, golden to cinnamon, echinulate, pores (4–)6–8, scattered; amphisori epiphyllous, elliptical or oblong, pulvinate, deep chestnut; amphispores (18–)20–25(–28) × (23–)25–30(–35) μ, mostly broadly ellipsoid or obovoid, wall (2.5–)3–3.5(–4) μ thick or the apex to 5 μ, closely and finely echinulate, chestnut, pores (4–)5–7, scattered or tending to be equatorial when 4. Telia epiphyllous, chestnut, pulvinate; teliospores (13–)16–19(–22) × (28–)32–40 (–43) μ, mostly oblong-ellipsoid, wall 1–1.5 μ thick at sides, (4–)5–7(–9) μ apically, golden, smooth; pedicels hyaline, thin-walled and collapsing, attaining 80 μ in length but usually broken shorter. The teliospores germinate without dormancy.

Hosts and distribution: *Stipa columbiana* Macoun, *S. lettermanii* Vasey, *S. occidentalis* Thurb., *S. richardsonii* Link, *S. robusta* (Vasey) Scribn., *S. viridula* Trin.: Minnesota to Alberta southward to Utah, Arizona and New Mexico.

Type: Baker (Ell. & Ev. N. Amer. Fungi No. 3141), on *Chrysopogon* sp. (= error for *Stipa viridula*), Fort Collins, Colo.

There are three relatively distinct varieties of *P. substerilis*, separable mainly on the size of the amphispores and teliospores. The variety *substerilis* has the smallest spores and both amphispores and teliospores have the thinnest walls. The amphispores are more closely echinulate (spines spaced 1.5–2.5 μ apart) than in the varieties *scribneri* and *oryzopsidis* (spines spaced 3–4 μ) and tend to be more densely pigmented. This variety ranges farther to the north and east than do the other two.



FIGS. 7–12. Teliospores and amphispores of *Puccinia*. 7. *P. substerilis* var. *substerilis*, teliospores (from Barth., N. Amer. Ured. No. 3363). 8. *P. substerilis* var. *substerilis*, amphispores (from same). 9. *P. substerilis* var. *scribneri*, amphispores (from type). 10. *P. substerilis* var. *oryzopsidis*, amphispores (from type). 11. *P. substerilis* var. *oryzopsidis*, teliospores (from type). 12. *P. entrerriana* (from type). All × 800.

PUCCINIA SUBSTERILIS Ell. & Ev. var. **scribneri** var. nov. (FIG. 9).

Amphisporis (19–)22–26(–30)×(23–)26–33(–38)μ, membrana (3–)3.5–4(–5)μ cr. vel ad apicem usque ad 6μ cr., remoteque echinulata, poris germ. (4–)5 vel 6(–7), sparsis; teliosporis (16–)18–21(–23)×(31–)35–44(–50)μ, membrana 1.5–2μ cr., ad apicem (5–)6–8(–9)μ.

Hosts and distribution: *Stipa scribneri* Vasey: Colorado and New Mexico.

Type: Bethel, Manitou, Colorado, Apr. 11, 1921.

This variety is intermediate between var. *substerilis* and var. *oryzopsidis*. Urediospores are common and similar to those of var. *substerilis* but the teliospores are longer and have slightly thicker walls. The amphispores also have typically scattered pores but the walls are thicker and more distantly echinulate (spines spaced 3–4 μ apart) and are less densely pigmented.

This variety appears to be restricted to *Stipa scribneri* and we have seen no collections from north of the Denver area and most are from Colorado Springs and southward.

PUCCINIA SUBSTERILIS var. **oryzopsidis** var. nov. (FIGS. 10, 11).

Urediosporis ignotis; amphisporis (18–)22–28(–30)×(25–)28–36(–43)μ, membrana (3–)3.5–4.5(–5.5)μ cr. vel ad apicem usque ad 6μ cr., remoteque echinulata, poris germ. 3 vel 4(–5) equatorialibus; teliosporis (17–)19–24(–26)×(32–)38–48(–56)μ, membrana 1.5–2(–3)μ, ad apicem (6–)7–9(–11)μ.

Hosts and distribution: *Oryzopsis hymenoides* (Roem. & Schult.) Ricker, *Stipa arida* M. E. Jones: Wyoming to Oregon and southward to New Mexico and California.

Type: Bethel (Barth. Fungi Columb. No. 5075), Victorville, California.

The teliospores are slightly larger and tend to be more deeply pigmented than those of the other varieties but they also germinate, at least in part, without dormancy. Urediospores have not been seen. The amphispores tend to be somewhat larger and thicker-walled than those of var. *scribneri* but the echinulation and color are similar. Germ pores are almost strictly equatorial. In specimens from northern Colorado and Wyoming the amphispores tend to be smaller, thinner-walled and darker than is typical but the germ pore arrangement is the same. In most collections the amphisori are larger and tend to be more confluent than is true of either of the two other varieties.

This variety is commoner south and southwest in the more arid regions.

There is considerable similarity between the urediospores and teliospores of *Puccinia substerilis* and those of *Puccinia monoica* Arth. This similarity may indicate that *P. substerilis* is an amphisporic derivative of *P. monoica* but there are neither inoculations nor field observation to substantiate such a suggestion. The species obviously persists without utilizing an aecial host.

9. PUCCINIA MONOICA Arth., Mycologia **4**: 61. 1912 (FIGS. 5, 6).
Aecidium parryi Pk., Amer. Nat. **8**: 215. 1874.
Aecidium monoicum Pk., Bot. Gaz. **4**: 230. 1879.
Aecidium auriellum Pk., Bull. Torrey Bot. Club **10**: 74. 1883.
Aecidium drabae Tracy & Gall., Jour. Mycol. **4**: 21. 1888.
Dicaeoma monoicum (Pk.) Arth. & Fromme, N. Amer. Flora **7**(4): 312. 1920.
Dicaeoma parryi (Pk.) Arth., N. Amer. Flora **7**(11): 778. 1926.

Spermogonia amphigenous. Aecia hypophyllous, systemic, cup-like or cylindrical, peridium white or yellowish; aeciospores (14–)18–23(–27)×(16–)23–26(–33)μ, mostly globoid or ellipsoid, wall (1–)1.5–2.5(–3.5)μ, hyaline or yellowish, verrucose. Uredia epiphyllous, cinnamon, pulverulent; urediospores (18–)22–26(–28)×(22–)26–30(–35)μ, mostly broadly ellipsoid, wall (1–)1.5–2.5(–4)μ, golden to cinnamon, echinulate, pores mostly 5–8, scattered or on *Stipa* many spores may have 3 or 4 equatorial pores. Telia mostly epiphyllous, pulvinate, mostly chocolate, usually greyish from germination; teliospores (16–)19–23(–27)×(33–)40–51(–63)μ, mostly oblong-ellipsoid, sometimes clavate-oblong; wall 1–1.5(–2.5)μ thick at sides, 5–10(–14)μ apically, golden or clear chestnut, smooth; pedicels hyaline or yellowish, thin-walled and collapsing, attaining 120 μ in length but usually 100 μ or less.

Hosts and distribution: (aecial stage): *Arabis bolanderi* Wats., *A. brachycarpa* (T. & G.) Britt., *A. canescens* Nutt., *A. connexa* Greene, *A. crandallii* B. L. Rob., *A. cusickii* Wats., *A. divaricarpa* A. Nels., *A. drummondii* Gray, *A. exilis* A. Nels., *A. fendleri* (Wats.) Greene, *A. glabra* Bernh.?, *A. lignifera* A. Nels., *A. lyallii* Wats., *A. lyrata* L., *A. nuttallii* B. L. Rob., *A. ovata* (Pursh) Poir., *A. perennans* Wats., *A. platysperma* Gray, *A. retrofracta* Graham, *A. selbyi* Rydb., *A. sparsiflora* Nutt., *A. whitedii* Piper, *Draba* sp., *Lepidium densiflorum* Schrad.?, *Phenocaulis cheiranthoides* Nutt., *P. pedicellata* (A. Nels.) Heller, *Schoenocrambe linifolia* (Nutt.) Greene, *Smelowskia calycina* Meyer, *Sophia canescens* (?), *S. incisa* (Engelm.) Greene, *S. leptostylis* Rydb., *S. pinnata* (Walt.) Howell, *Thelypodium linearifolium* Wats., *Thlaspi glaucum* A. Nels.; (telial stage): *Koeleria cristata* (L.) Pers.,

Oryzopsis hymenoides (Roem. & Schult.) Ricker, *Stipa californica* Merr. & Davy, *S. elmeri* Piper & Brodie, *S. occidentalis* Thurb., *Trisetum spicatum* (L.) Richter: Wisconsin to British Columbia southward to New Mexico and California.

Type: Garrett (Fungi Utahenses No. 194), on *Trisetum spicatum* (*T. subspicatum* (L.) Beauv.), Big Cottonwood Canyon, Salt Lake County, Utah.

Following field observations by E. Bethel in Colorado and A. O. Garrett in Utah, successful reciprocal inoculations were made by Arthur (Mycologia **4**: 59–61. 1921) using *Arabis* sp. and *Trisetum spicatum* (*T. majus*) and (Mycologia **6**: 75. 1915) using *Arabis* sp. and *Koeleria cristata*. Mains (Mycologia **25**: 407–408. 1933) obtained aecia on *Arabis* sp. using telial material from *Stipa* sp. (= *S. occidentalis*) and obtained infection of *Koeleria cristata* by using aecispores from *Arabis* sp. Mains recognized f. sp. *koeleriae* and f. sp. *triseti* and suggested that the rust on *Stipa* probably represented another race. Notes in the Arthur Herbarium indicate that Bethel and Mrs. M. S. Clemens were convinced, on the basis of field observations, of the *Arabis-Stipa* relationship. The junior author on many occasions observed an intimate association of rusted *Arabis-Koeleria* and *Arabis-Trisetum* in Montana (1955) and Colorado (1956).

The telia are usually in scattered groups on *Koeleria* and *Trisetum* but on *Oryzopsis* and *Stipa* they are seriately arranged over extensive areas of the leaves.

Occasional collections have some urediospores with amphisporic characteristics. As pointed out under *P. substerilis* it is possible that the species represents an amphisporic derivative of *P. monoica*. Both are remarkably similar morphologically.

Collections on *Oryzopsis* have been assigned to *Puccinia stipae* previously but we consider that the golden-brown teliospores which germinate without over-wintering indicate *P. monoica*. Moreover, Bethel on three occasions noted that rusted *Arabis* was associated with rusted *Oryzopsis*.

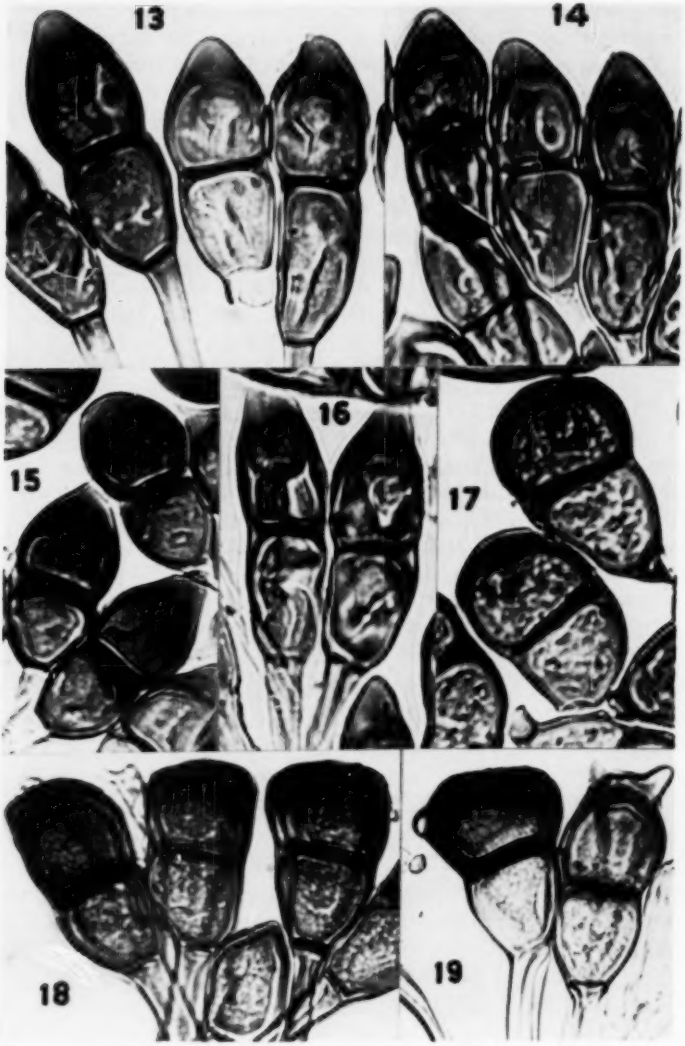
10. PUCCINIA STIPAE Arth., Iowa Agric. Coll. Dept. Bot. Bull. **1884**: 160. 1884, var. **stipae** (FIG. 13).

Aecidium bigeloviae Pk., Bot. Gaz. **3**: 35. 1878.

Aecidium crepidicola Ell. & Gall., Jour. Mycol. **6**: 31. 1890.

Aecidium compositarum lygodesmiae Webber, Saccardo Syll. Fung. **9**: 323. 1891.

Aecidium chrysopsidis Ell. & And., Bot. Gaz. **16**: 48. 1891.



FIGS. 13-19. Teliospores of *Puccinia*. 13. *P. stipae* var. *stipae* (from type). 14. *P. stipae* var. *stipina* (from Sydow, Uredineen No. 28). 15. *P. stipae* var. *stipae-sibiricae* (from type). 16. *P. lasiagrostis* (from type). 17. *P. flavescens* (from type). 18. *P. mexicensis* (from type). 19. *P. neocoronata* (from type). All × 800.

Aecidium solidaginicola Ell. & Ev., Erythea **1**: 216. 1893.
Aecidium sclerothecioides Ell. & Ev., Am. Nat. **31**: 428. 1897.
Dicaeoma stipae (Arth.) Kuntze, Rev. Gen. **3**: 470. 1898.
Aecidium lygodesmiae (Webber) Shear, Ell. & Ev. Fungi Columb. No. 1476. 1901.
Aecidium incurvum Tracy & Earle, Greene Plantae Baker. **1**: 18. 1901.
Aecidium grindeliae D. Griff., Bull. Torrey Bot. Club **29**: 299. 1902.
Aecidium recedens Arth., Bull. Torrey Bot. Club **31**: 7. 1904.

Spermogonia amphigenous. Aecia amphigenous, often causing slight hypertrophy; peridia protruding from slight hemispherical elevations of the host tissue, white or yellowish, bag-shaped, variously lacerate and often breaking at the pore-like opening in the host; peridial cells labyrinthiformly and coarsely verrucose with irregular ridges and tesselate warts; aeciospores (15–)22–26(–33) × (17–)23–28(–36)μ, mostly globoid or broadly ellipsoid, wall (1–)2.5–3.5(–5)μ, mostly yellowish to golden, verrucose. Uredia epiphyllous, pulverulent, about cinnamon; urediospores (16–)20–23(–30) × (19–)23–26(–36)μ, mostly broadly ellipsoid or globoid, wall (1–)1.5–2.5(–3.5)μ, golden to cinnamon, echinulate, pores (4–)6–8(–10), scattered. Telia like the uredia but blackish and pulvinate; teliospores (17–)20–25(–33) × (33–)43–53(–82)μ, mostly ellipsoid or oblong-ellipsoid, wall 1.5–2.5(–3.5)μ thick at sides, (4–)5–10(–14)μ apically, chestnut, smooth; pedicels rather thin-walled and mostly collapsing, yellowish to golden, attaining 175μ in length, usually exceeding 100μ.

Hosts and distribution: (aecial stage): *Agoseris arizonica* Greene, *A. laciniata* (Nutt.) Greene, *Aster amethystinus* Nutt., *A. azureus* Lindl., *A. ericoides* L. (*A. multiflorus* Ait.), *A. exiguus* (Fern.) Rydb., *A. laevis* L., *A. oblongifolius* Nutt., *A. porteri* Gray, *Chrysopsis villosa* (Pursh) Nutt., *Chrysothamnus graveolens* (Nutt.) Greene, *Crepis acuminata* Nutt., *C. glauca* (Nutt.) T. & G., *Erigeron caespitosus* Nutt., *E. corymbosus* Nutt., *E. flagellaris* Gray, *E. pumilus* Nutt., *Grindelia squarrosa* (Pursh) Dunal, *Guterrezia sarothrae* (Pursh) Britt. & Rusby, *Hymenopappus arenosus* Heller, *Lygodesmia juncea* (Pursh) D. Don, *Oligoneuron canescens* Rydb., *Senecio densus* Greene, *S. intergerrimus* Nutt., *S. oblanceolatus* Rydb., *S. perplexus* A. Nels., *S. pudicus* Greene, *S. riddellii* T. & G., *S. salicinus* Rydb., *S. spartioides* T. & G., *Sideranthus grindelioides* (Hook.) Rydb., *Solidago concinna* A. Nels., *S. elongata* Nutt., *S. glaberrima* Martens, *S. mollis* Bartl., *S. rigida* L., *Tetraneuris arizonica* Greene, *Townsendia grandiflora* Nutt.; (telial stage): *Stipa californica* Merr. & Davy, *S. columbiana* Macoun, *S. comata* Trin. & Rupr., *S. eminens* Cav., *S. ichu* (Ruiz & Pav.) Kunth,

S. leucotricha Trin. & Rupr., *S. neomexicana* (Thurb.) Scribn., *S. pulchra* Hitchc., *S. richardsonii* Link, *S. spartea* Trin., *S. viridula* Trin.: Indiana westward to Alberta and Baja California and in Bolivia.

Type: Bessey, on *Stipa spartea,* Ames, Iowa.

Arthur (Jour. Mycol. **11**: 63–64. 1905; Mycologia **4**: 19. 1912; Mycologia **7**: 72. 1915), using teliospores from *Stipa spartea,* produced aecia on *Aster* spp.; using teliospores from *Stipa comata,* he produced aecia on *Aster* spp. and *Solidago canadensis* and with teliospores from *Stipa* sp. he produced aecia on *Grindelia squarrosa* (Mycologia **4**: 19. 1912); using teliospores from *Stipa comata* he produced aecia on *Gutierrezia sarothrae* and *Senecio lugens.* In 1912 he also reported using teliospores from *Koeleria cristata* to produce aecia on *Senecio lugens* but we believe that there is some error in this record. The rust on the collection which supposedly was used is *Puccinia monoica.* Davis (Trans. Wis. Acad. Sci. **20**: 422. 1922), using teliospores from *Stipa spartea,* produced aecia on *Aster ericoides* (*A. multiflorus*). Cummins in 1955 at Polson, Montana, used aeciospores from *Erigeron corymbosus* to infect *Stipa comata* in field inoculations.

Oryzopsis hymenoides and *Koeleria cristata* have been considered to be hosts of *P. stipae.* It is our opinion, however, that the rust is *P. monoica.*

Since *Puccinia stipina* Tranz. and *P. stipae-sibiricae* Ito differ in no important respect we are treating them as varieties based upon slight differences in the size of spores.

PUCCINIA STIPAE Arth. var. **stipina** (Tranz.) comb. nov. (FIG. 14).

Puccinia graminis foliorum stipae Opiz, Seznam. Rost. Kvet. Ceské, p. 138. 1852, *nom. nud.*

Puccinia stipae (Opiz) Hora, Sydow, Uredineen No. 28. 1888, *nom. nud.*

Aecidium thymi Fckl., Nass. Ver. Naturk. Jahrb. **23–24**: 376. 1870.

Puccinia stipina Tranz., Trav. Mus. Bot. Acad. Imp. Sci. St. Peterb. **7**: 114. 1909, *nom. nud.*

Puccinia stipina Tranz. ex Klebahn, Kryptogfl. Mark. Brandenburg **5a**: 477. 1913.

Aecia as in var. *stipae;* peridial cells more finely verrucose; aeciospores (15–)18–21(–25) × (17–)21–23(–30) μ, wall 1–1.5(–3) μ thick, pores (3–)4–6(–8), scattered; urediospores (16–)19–22(–25) × (18–)21–24(–30) μ; teliospores (17–)20–24(–27) × (36–)45–56(–67) μ, pale spores usually longer than darker spores, wall 1.5–2 μ thick at sides, 5–10 μ apically, golden to chestnut; pedicels hyaline or yellowish, attaining 140 μ in length.

Hosts and distribution: (aecial stage): *Ajuga chia* Schreb., *Dracocephalum nutans* L., *D. thymiflorum* L., *Lallemantia iberica* Fish. & Mey., *Lamium purpureum* L., *L. amplexicaule* L., *Leonurus tataricus* L., *L. lanatus* Spreng., *Origanum vulgare* L., *Phlomis tuberosa* L., *Salvia aethiopsis* L., *S. dumetorum* Andrz., *S. nemorosa* L. (*S. silvestris* Auth.), *S. nutans* L., *S. pratensis* L., *S. silvestris* L., *Thymus cimicinus* Blum.?, *T. herba-barona* Loisel. (*T. marschallianus* Willd.), *T. serphyllum* L. (*T. glabrescens* Benth.), *T. praecox* Opiz, *Ziziphora clinopodioides* Lam.; (telial stage): *Stipa capillata* L., *S. dasyphylla* Czern., *S. pennata* L. (*S. gallica* Celak), *S. pulcherrima* C. Koch, *S. szovitsiana* Trin.: Switzerland and France eastward to south central Siberia and perhaps Manchuria and China.

Type: Diedicke, on *Stipa capillata*, Schwellenburg bei Erfurt, Thuringen, Germany (Sydow, Mycoth. Germ. No. 563 as *Puccinia stipae*).

Tranzschel (Consp. Ured. U.R.S.S. p. 189, 190. 1939) indicates that *Aecidium pulsatillae* Tranz., occurring on *Pulsatilla patens* (L.) Mill, *P. chinensis* (Bge.) Reg., *P. dahurica* Spreng., and *P. turczaninowii* Kryl. & Serg., and perhaps *Aecidium tranzschelianum* Lindr., on *Geranium sanguineum* L. also may belong in the life-cycle. The latter fungus has been cited as *Puccinia oertelianum* Tranz. but the name has not been published.

Bubák (Centrlbl. Bakt. II. **9**: 917. 1902) first demonstrated the life cycle of this rust using aeciospores from *Thymus ovatus* and producing uredia on *Stipa capillata*. Diedicke (Ann. Mycol. **1**: 341. 1903) used teliospores from *S. capillata* and produced aecia on *Salvia silvestris* and Klebahn (Die Wirtswechselnden Rostpilze p. 272. 1904) used similar telial material and produced aecia on *S. silvestris* and *S. pratensis*. Gäumann (Boissiera **7**: 112–119. 1943) demonstrated that *Thymus serpyllum, T. alpestris, T. vulgaris* and *Origanum vulgare* are susceptible. There have been recognized f. spp. *thymi-stipae, salviae-stipae,* and *gallicae*.

This variety has teliospores about the size of var. *stipae* but they are usually slightly paler and the aeciospores and urediospores are smaller.

PUCCINIA STIPAE Arth. var. **stipae-sibiricae** (Ito) comb. nov. (FIG. 15).

Aecidium libanotidis Thuem., Bull. Soc. Imp. Nat. Moscow **55**: 206. 1880.

Puccinia stipae-sibiricae Ito, Jour. Coll. Agric. Tohoku Imp. Univ. **3**: 228. 1909.

Aecidium sedi-aizoontis Tranz., Trav. Mus. Bot. Acad. Imp. Sci. St. Petersb. **7**: 111. 1909.

Aecia as in var. *stipae*, peridial cells longitudinally and labyrinthiformly ridged; aeciospores (15–)17–21(–22) × (16–)18–26(–30) μ, mostly globoid or nearly so, wall (2–)3–4(–5) μ thick, pores (4–)5–7, scattered; urediospores (15–)16–20(–22) × (16–)18–23(–26) μ, pores (3–)4–6(–7), scattered; teliospores (15–)18–23(–25) × (34–)36–50 (–59) μ, wall (1–)1.5–2(–3.5) μ at sides, 6–10(–14) μ apically, golden to clear chestnut, smooth; pedicels attaining 135 μ but usually less than 100 μ in length.

Hosts and distribution: (aecial stage): *Carum buriaticum* Turcz., *Libanotis sibirica* C. A. Mey., *Pachypleurum alpinum* Lebeb., *Peucedanum baicalense* Koch, *Ploiodicarpus dahuricus* Turcz., *Sedum aizoon* L., *S. kamtschaticum* Fish. & Mey., *Siler divaricatum* Benth. & Hook.: (telial stage): *Stipa effusa* Nakai, *S. extremiorientalis* Hara, *S. sibirica* Lam.: Central Siberia to Manchuria and Japan.

Type: Miyabe, on *S. effusa*, Sapporo, Prov. Ishikari, Japan.

Tranzschel (Mycol. Centralb. **4**: 70. 1914), using teliospores from Transbaikalia, produced aecia on *Sedum aizoon*. At this time he recognized f. sp. *sedi-stipae-sibiricae* and later (Notulae Syst. Inst. Cryptog. Hort. Bot. Petrop. II. **6**: 83. 1923) also f. sp. *umbelliferarum-stipae-sibiricae* and f. sp. *stenocoelii-stipae-sibericae* after successful infection of *Siler divaricatum* (*Stenocoelium divaricatum*) but not *Libanotis sibirica*, *Peucedanum baikalensis*, and *Carum buriaticum*.

This variety has smaller teliospores than var. *stipae* and var. *stipina*. The urediospores and aeciospores are about the same size as or slightly smaller than those of var. *stipina*.

11. PUCCINIA LASIAGROSTIS Tranz., Consp. Ured. U.R.S.S. p. 96. 1939 (FIG. 16).

Puccinia lasiagrostis Tranz., Notulae Syst. Inst. Cryptog. Hort. Bot. Petrop. II. **6**: 83. 1923, *nom. nud.*

Spermogonia epiphyllous. Aecia hypophyllous and on petioles, in groups, peridium protruding from slight hemispherical elevations of the host tissue, cylindrical or sack-like but becoming lacerate into filaments, peridial cells reaching 80 μ in length, almost roestelioid, yellowish brown; aeciospores (21–)23–27(–29) × 26–34(–38) μ, ellipsoid to globoid, wall 1.5–2 μ thick, golden, finely and reticulately or labyrinthiformly verrucose, pores conspicuous, 6–10. Uredia (after Tranzschel) epiphyllous, oblong, ferruginous; urediospores 20–35 μ diam., globoid or ellipsoid, wall (thickness not stated) "flavidulis," echinulate, pores several (presumably scattered). Telia epiphyllous and on sheaths, early exposed, pulvinate, blackish, oblong or linear and attaining a length of 5 mm.;

teliospores (15–)19–27(–30) × (40–)50–70(–76) μ, cylindrical, fusiform or long-clavate, chestnut, wall 1.5–2(–3) μ thick at sides, 5–12(–14) μ apically, the apical thickening becoming progressively paler externally, smooth; pedicels hyaline or yellowish, thick-walled and mostly not collapsing, attaining 175 μ in length.

Hosts and distribution: (aecial stage): *Artemisia commutata* Bess., *A. scoparium* W. & K., *A. sieversiana* Willd., *Chrysanthemum sibericum* Fisch. (and perhaps also *Lactuca saligna* L., *Taraxacum bicorne* Dahlst., and *T. glaucanthum* (Ledeb.) DC.); (telial stage): *Stipa splendens* Trin.: southern U.S.S.R. from Kirgiz region to Buryat-Mongol'skaya and China (?).

Type: Tranzschel, on *Stipa splendens,* Buryat-Mongolia near Kiachta.

Tranzschel (Notulae Syst. Inst. Cryptog. Hort. Bot. Petrop. II. **6**: 83. 1923) successfully infected *Artemisia campestris.*

This species is generally similar to *P. stipae* but differs in having all spores larger. The teliospores are definitely longer and have thick-walled non-collapsing pedicels.

The possible Chinese record (on *Stipa splendens,* Peking) was published by Liou and Wang (Contr. Inst. Bot. Natl. Acad. Peking **3**: 23. 1935) who gave the teliospore size as 20–25 × 45–70 μ.

12. **Puccinia mexicensis** sp. nov. (FIG. 18).

Aeciis ignotis. Urediis epiphyllis, flavidis, pulverulentis, 0.5–1 mm longis, paraphysibus nullis; urediosporis (16–)17–20 × (17–)19–23(–24) μ, plerumque late ellipsoideis vel globoideis, membranis 1–1.5 μ cr., hyalinis vel pallide flavidis, minuteque echinulatis, poris germ. 7 vel 8, sparsis. Teliis hypophyllis, atro-brunneis, compactis, pulvinatis, elongatis, 0.5–2 mm longis; teliosporis (16–)20–27(–30) × (31–)35–45(–53) μ, clavatis vel oblongo-clavatis, ad apicem truncatis vel rotundato-truncatis, membranis 1.5–2(–3) μ cr., ad apicem (4–)6–9(–10) μ cr., castaneo-brunneis, levibus; pedicello brunneolo, persistenti, (15–)25–40(–50) μ longo.

Hosts and distribution: *Stipa constricta* Hitchc., *S. eminens* Cav.: Mexico.

Type: Lyonnet No. 1957, on *S. constricta,* Lomas de Michoac, Dist., Fed., Mexico.

We have seen four collections of this species, all from central to south central Mexico, and three of them were taken from phanerogamic specimens in the U. S. National Herbarium.

This is the only species on *Stipa* which produces its telia on the abaxial surface of the leaves. The small urediospores and broadly clavate "stubby" teliospores with short brown pedicels distinguish this fungus from others of Group VI. *P. micrantha* Griff., which occurs on

Oryzopsis micrantha (Trin. & Rupr.) Thurb., has spores of approximately the same sizes but the urediospores are brownish and the teliospores are not bluntly clavate and have longer hyaline pedicels.

13. PUCCINIA FLAVESCENS McAlp., Proc. Linn. Soc. New S. Wales **28**: 558. 1903 (FIG. 17).

Aecia unknown. Uredia epiphyllous, cinnamon, pulverulent; urediospores (20–)22–25 × (22–)24–28(–33) μ, mostly globoid, wall 1–1.5 (–2.5) μ thick, golden to cinnamon, echinulate, pores 4–7, scattered. Telia epiphyllous, early exposed, pulvinate, blackish, elliptical, 0.5 mm or less in length; teliospores (19–)22–25(–29) × (35–)38–46(–50) μ, mostly ellipsoid, wall 1–1.5(–2) μ thick at sides, (4–)5–7(–8) μ apically, dark chestnut, smooth; pedicels yellowish or brownish, thin-walled and mostly collapsing, attaining a length of 85 μ but usually broken shorter.

Hosts and distribution: *Stipa flavescens* Lobell, *S. semibarbata* R. Br.: Australia.

Type: McAlpine, on *Stipa flavescens*, Hampton, Victoria, Australia.

The urediospores are similar to those of *P. stipae* var. *stipina* but have thinner walls. The teliospores are more robust than any of the varieties of *P. stipae*, are more broadly rounded apically, have a thinner apical wall, and have fragile pedicels which are usually broken near or at the hilum.

14. **Puccinia neocoronata** sp. nov. (FIG. 19).

Aeciis ignotis. Urediis amphigenis, linearibus, usque ad 1 mm longis, cinnamomeo-brunneis, pulverulentis, paraphysibus nullis; urediosporis (21–)23–26(–29) × (25–)28–33(–36) μ, ellipsoideis, late ellipsoideis, vel plus minusve globoideis, membranis 1.5–2(2.5) μ cr., cinnamomeo-brunneis, echinulatis, poris germ. 5–7, sparsis. Teliis amphigenis, linearibus, usque ad 2 mm longis, atro-brunneis, compactis, pulvinatis; teliosporis (14–)17–23(–26) × (30–)37–46(–60) μ, plerumque clavatis vel oblongo-clavatis, ad apicem truncatis, rotundato-truncatis, vel rarius acuminatis, irregulariter coronatis, 1.5–2.5(–3.5) μ cr., ad apicem (4–)6–9(–13) μ cr., castaneo-brunneis, levibus; pedicello flavidulo, persistenti, (15–)20–40(–50) μ longo, crassiusculo.

Hosts and distribution: *Piptochaetium fimbriatum* (HBK) Hitchc., *Stipa pringlei* Scribn.: southern Arizona and northern (Sonora) Mexico.

Type: W. G. and Ragnild Solheim No. 2453 (Solheim, Mycofl. Saximont. Exs. No. 589, as *P. stipae* Arth.), Santa Catalina Mts., Pima Co., Arizona.

Digitations on the teliospore vary from none to five, with two or

three the commoner numbers. When present they may vary from barely perceptible to 9 μ in length. When digitations are absent the apex may be rounded, truncate, or acuminate. It is probable, despite the "corona," that the species is not related to *P. coronata* Cda. The telia are early exposed and the teliospore pedicels are long. The digitations resemble those of *P. asperellae-japonicae* Hara, which occurs on *Hystrix hackelii* Honda, but the two species are otherwise different.

The rust fungus on *Piptochaetium fimbriatum* has urediospores which average smaller than that on *Stipa*. The collection was made by the Solheims in the Chiricahua Mts., south and east of the type locality.

15. PUCCINIA WOLGENSIS Nawasch., Uebers. Leist. Bot. Russland 1892: 146. 1894 (FIG. 20).

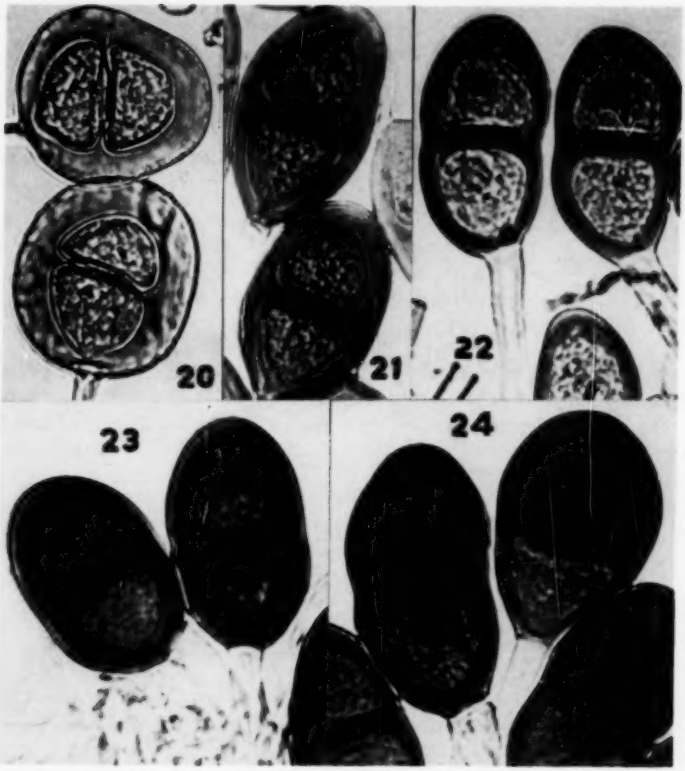
Aecia unknown. Uredia not seen; urediospores in the telia, 23–25 × 25–28(–30) μ, broadly ellipsoid or globoid, wall 2–3 μ thick, golden, echinulate, pores 6 or 7, scattered. Telia epiphyllous, early exposed, pulvinate, chestnut or yellowish brown; teliospores (30–)34–50(–58) × (36–)40–63(–73) μ, broadly ellipsoid, wall uniformly (5–)8–10(–16) μ thick, golden, indistinctly rugose or punctate or appearing smooth; pedicels hyaline, thin-walled and collapsing, attaining a length of at least 125 μ but fragile and breaking near the spore.

Hosts and distribution: *Stipa barbata* Desf., *S. hohenhackeriana* Trin. & Rupr., *S. lagascae* Roem. & Schult., *S. lessingiana* Trin. & Rupr., *S. orientalis* Trin.?, *S. pennata* L., *S. subbarbata* Keller: southern U.S.S.R., Syria and Morocco.

Type: Nawaschin, on *S. pennata*, Saratov, U.S.S.R.

P. wolgensis, because of its broad, very thick-walled and verrucose teliospores, is completely unlike the other rusts of *Stipa*. *P. pratensis* Blytt and *P. versicoloris* Semadeni have somewhat the same characteristics but are not identical.

We have been unable to obtain the original publication of Nawaschin. The Sydows (Monogr. Ured. 1(4): 819. 1903) cite the above publication but Tranzschel (Consp. Ured. U.R.S.S. 101. 1939) gives the Sydow's Monograph as the place of publication. This would indicate that Nawaschin did not publish a description. The type specimen in the Stockholm Museum contains a Latin description and Nawaschin's signature.



FIGS. 20–24. Teliospores of *Puccinia*. 20. *P. wolgensis* (from type). 21. *P. avocensis* (from type). 22. *P. interveniens* (from type). 23. *P. pazensis* (from type). 24. *P. graminella* (from type). All × 800.

16. **Puccinia pazensis** sp. nov. (FIG. 23).

Spermogoniis et aeciis ignotis. Urediis epiphyllis, ellipticis, usque ad 5 mm longis, flavidis, pulverulentis, paraphysibus nullis; urediosporis (16–)20–24(–26) ×23–28 μ, globoideis vel late ellipsoideis, membranis (3–)4–6(–7) μ crassis, hyalinis vel pallide flavidis, labyrinthiformiter verrucosis, poris germ. obscuris, sparsis. Teliis urediis similibus sed atro-brunneis et pulvinatis; teliosporis (24–)27–30(–32) ×(36–)42–48(–54) μ, plerumque late ellipsoideis, membranis 2.5–5 μ crassis, ad apicem 6–8(–10) μ crassis, obscure aureis vel lucide castaneo-brunneis, minuteque verrucosis vel apparenter levibus; pedicellis hyalinis, usque ad 135 μ longis, tenuiter tunicatis.

Hosts and distribution: *Nasella pubiflora* (Trin. & Rupr.) Desv.: Bolivia.

Type: Holway No. 479, La Paz, Bolivia.

This rust was assigned to *P. digna* by Arthur, Amer. Phil. Soc. Proc. **64**: 198. 1925, and also was illustrated (f. 6). The species is distinctive because of the verrucose aeciospore-like urediospores and the minutely verrucose teliospores.

17. PUCCINIA AVOCENSIS Cumm. & H. C. Greene, in Greene, Trans. Wis. Acad. Sci. Arts, Letters **43**: 177. 1954 (FIG. 21).

Aecidium avocense Cumm. & H. C. Greene, in Greene, Trans. Wis. Acad. Sci. Arts, Letters **43**: 176. 1954.

Spermogonia unknown. Aecia hypophyllous, tending to be grouped along the veins, peridia protruding from slight hemispherical elevations of the host tissue, more or less bag-like, whitish or yellowish, becoming lacerate; aeciospores (13–)15–20 × (–13)16–21(–23)μ, mostly globoid, wall (2–)3–3.5 μ thick, hyaline or pale yellowish, verrucose with rounded warts or these sometimes labyrinthiformly confluent. Uredia probably not formed. Telia epiphyllous, dark cinnamon, deeply pulvinate, fusiform and attaining a length of 2 cm; teliospores (19–)25–28(–32) × (32–)37–44(–50)μ, mostly broadly ellipsoid and moderately rounded at each end, wall uniformly (2–)3–4(–5)μ thick or only slightly thicker apically, pale chestnut or golden, smooth; pedicels hyaline, thin-walled and collapsing, exceeding 100 μ in length but always broken near the spore.

Hosts and distribution: (aecial stage): *Callirhoe triangulata* (Leavenw.) Gray; (telial stage): *Stipa spartea* Trin.: Wisconsin, U.S.A.

Type: H. C. Greene, Avoca, Iowa Co., Wisconsin.

Close association of the aecia and telia in the field indicates that they are stages of a single species but this has not been proved. Inoculation experiments by the senior author were not successful.

The species differs from *P. interveniens* in having teliospores with a uniform or nearly uniformly thick wall and pedicels which are thin-walled and usually broken near the spore. It is probably related, however.

18. PUCCINIA INTERVENIENS Bethel, in Blasdale, Univ. Calif. Publ. Bot. **7**: 119. 1919 (FIG. 22).

Aecidium modiolae Thuem., Flora **63**: 31. 1880.

Roestelia interveniens Pk., Bull. Torrey Bot. Club **10**: 74. 1883.

Aecidium roestelioides Ell. & Ev., Jour. Mycol. **1**: 93. 1885.

Aecidium modiolae sphaeralceae P. Henn., Hedwigia **34**: 322. 1895.
Aecidium malvastri P. Henn., Hedwigia **36**: 216. 1897.
Aecidium malvastricola P. Henn. ex Saccardo & Sydow, Sacc. Syll. Fung. **14**: 371. 1899.
Aecidium interveniens (Pk.) Farl., Bibl. Index **1**: 58. 1905.
Aecidium sphaeralceae Speg., An. Mus. Nac. Buenos Aires **19**: 322. 1909.
Aecidium sphaeralceanum Sacc. & Trott., Sacc. Syll. Fung. **21**: 756. 1912.
Dicaeoma interveniens (Pk.) Arth. & Fromme, N. Am. Flora **7**: 299. 1920.
Puccinia stipicola Speg., Rev. Argent. Bot. **1**: 126. 1925.
Puccinia stipicida Speg., Rev. Argent. Bot. **1**: 125. 1925.
Allodus interveniens (Pk.) Arth. & Orton, N. Am. Flora **7**: 797. 1927.

Spermogonia amphigenous. Aecia hypophyllous and caulicolous, in groups, peridia protruding from slight hemispherical elevations of the host tissue, whitish to yellowish, usually lacerated into filaments; aeciospores (13–)20–23(–30) × (15–)22–26(–33) μ, mostly globoid, wall (2.5–)3.5–5(–7) μ thick, hyaline or yellowish, finely and labyrinthiformly verrucose or rugose. Uredia not produced. Telia epiphyllous, deeply pulvinate, chestnut to chocolate, linear or long fusiform, attaining as much as 5 cm in length; teliospores variable, tending to be dimorphic, resting type (23–)26–30(–36) × (33–)42–47(–56) μ, mostly broadly ellipsoid or ellipsoid, wall 2–3 μ thick at sides, 3–12 μ apically, clear chestnut or deep golden; germinating type (15–)23–26(–33) × (43–)53–60(–80) μ, wall 2–2.5 μ thick at sides, 4–20 μ apically, mostly golden, smooth in both types; pedicels hyaline or yellowish, moderately thick-walled and usually not collapsing, attaining 200 μ or more in length.

Hosts and distribution: (aecial stage): *Callirhoe alceoides* (Michx.) Gray, *C. digitata* Nutt., *Iliamna rivularis* (Dougl.) Greene, *Malvastrum capitatum* (Cav.) Griseb., *M. fasciculatum* (Nutt.) Greene, *M. marrubioides* Dur. & Hilg., *M. spicatum* Gray, *Modiola caroliniana* (L.) Don, *M. geranioides* Walp., *Nototriche caesia* Hill, *N. niederlandii* Hill, *Sidalcea asprella* Greene, *S. candida* Gray, *S. crenulata* Nels., *S. malvaeflora* (Moc. & Sessé) Gray, *S. neomexicana* Gray, *S. nervata* Nels., *S. spicata* Greene, *Sphaeralcea australis* Speg., *S. bonariensis* Gris., *S. miniata* (Cav.) Spach, *S. obtusiloba* G. Don, *Tarassa antofagastana* (Phil.) Krap., *Wissadula conjugans* R. Fr.; (telial stage): *Nasella chilensis* (Trin. & Rupr.) Desv., *Stipa cacheutensis* Speg., *S. columbiana* Macoun, *S. comata* Trin. & Rupr. (?), *S. diegoensis* Swallen, *S. eminens*

The type specimen has not been available; hence the description is adapted from the original text and f. 15.

The specimen of *S. barbata* was obtained from a phanerogamic collection in the U. S. National Herbarium and was collected by D. Fairchild in Morocco in 1925. Only a single fusiform telium 4 mm in length was present and no urediospores were seen. The teliospores (FIG. 30) apparently are similar to those of *U. ferganensis*, being oval or broadly ellipsoid and measuring (20–)21–26 × (23–)27–30(–35) μ; the wall is (1.5–)2–2.5(–3.5) μ at sides and 4–6(–8) μ apically; the pedicels thin-walled and collapsing and, while they attain a length of at least 135 μ, most are broken much shorter. In color the teliospores are deep golden or clear chestnut.

The Moroccan specimen may not represent *U. ferganensis*, despite an apparent similarity of the teliospores. The large sori are not like the telia of *U. graminis* (Niessl) Diet., a species which Tranzschel suggests is similar.

23. UROMYCES MUSSOORIENSIS H. & P. Syd., in Sydow and Butler, Ann. Mycol. **4**: 430. 1906 (FIG. 29).

Aecia unknown. Uredia hypophyllous, pulverulent-pulvinate, yellowish brown; urediospores (15–)18–21(–23) × (17–)19–24(–25) μ, broadly ellipsoid or globoid, wall 2–2.5(–3) μ thick, yellowish to golden, verrucose, mostly striately so, pores obscure and difficult to count, apparently 3 or 4 and equatorial. Telia like the uredia but blackish and pulvinate; teliospores (16–)18–23(–25) × (19–)23–27(–28) μ, oval, broadly ellipsoid, or globoid, wall 1.5–2.5(–3) μ thick at sides, (3–)5–7(–8) μ apically, deep golden to clear chestnut, smooth; pedicels thin-walled, mostly collapsing, hyaline or yellowish, attaining a length of 65 μ.

Hosts and distribution: *Stipa sibirica* Lam.: India.

Type: Butler No. 542, Mussoorie.

This is the only species of *Uromyces* with verrucose urediospores which is known to occur on *Stipa*.

24. UROMYCES STIPINUS Tranz. & Eremeeva, in Tranzschel, Consp. Ured. U.R.S.S. 101. 1939.

Sori not described; teliospores 16–21 × 24–32 μ, oval, oblong-ellipsoid or broadly ellipsoid, wall (1.5–2 μ?) thick at sides, 8?–11 μ apically, golden? (dilute-brunneis), smooth; pedicels fragile, broken short, as illustrated probably thin-walled and collapsing, hyaline.

Hosts and distribution: *Stipa* (*rubens* Smirn.?): U.S.S.R.

Type: collector?, Mt. Karkaraly, Kazakh.

The specimen has not been available; hence the description is adapted from the original text and f. 17. Judging from Tranzschel's illustration the apical thickening is probably a pale and well-differentiated umbo. *U. stipinus* is probably not similar to other species on *Stipa*.

25. **Uredo nasellae** sp. nov.

Soris epiphyllis, flavidis, pulverulentis, usque ad 1 mm longis, ellipticis, paraphysibus nullis; urediosporis (18–)19–23(–25)×(22–)24–30(–33)μ, ellipsoideis, obovoideis vel late ellipsoideis, membranis 1(–1.5)μ cr., echinulatis, hyalinis vel flavidulis, poris germ. 7–10, sparsis, obscuris.

Hosts and distribution: *Nasella pubiflora* (Trin. & Rupr.) Desv.: Bolivia.

Type: Holway No. 420, La Paz, Bolivia.

This fungus, known from the type and Holway No. 419, was reported by Arthur, Proc. Amer. Phil. Soc. **64**: 198. 1925, as *Puccinia digna* but it has no paraphyses. It differs from other species treated under Group VI because of the mostly ellipsoid or obovoid pale spores.

EXCLUDED AND DOUBTFUL SPECIES

Puccinia oligocarpa Syd. & Butl., Ann. Mycol. **10**: 262. 1912.

The characteristics of this fungus lead us to question the identity of the host plant. The type specimen was examined by Dr. J. R. Swallen of the U. S. National Herbarium and, although the grass is sterile, he expressed the opinion that it was not *Stipa* but probably a species of *Calamagrostis*. The fungus is related to or perhaps identical with *Puccinia pygmaea* Eriks.

Uredo stipae Jacz., Bull. Soc. Mycol. France **9**: 49. 1893.

This fungus was described as "Soris hypophyllis, nervis parallele dispositis; sporis globoso-ovoideis, levibus, brunneis, 25 × 22½." The host was reported as *Stipa tenacissima* L. and the locality as Algeria.

We have not seen this fungus, nor did the Sydows (Monogr. Ured. **4**: 549. 1924). The description is too incomplete to give any clue as to possible relationships. If the spores are smooth it would be a most unusual grass rust fungus.

Uromyces argentinus Speg., An. Soc. Cient. Argentina **9**: 170. 1880.

This fungus is *Puccinia cacao* McAlp. and the host plant is *Hemarthria altissima* (Poir.) Stapf & Hubb. as pointed out by Lindquist (Rev. Faculty Agron. **29**: 36. 1953).

DEPARTMENT OF BOTANY
UNIVERSITY OF WISCONSIN
MADISON, WISCONSIN
AND
DEPARTMENT OF BOTANY AND PLANT PATHOLOGY
PURDUE UNIVERSITY
LAFAYETTE, INDIANA

NEW SPECIES AND VARIETIES OF CLITOCYBE FROM MICHIGAN [1]

HOWARD E. BIGELOW [2]

(WITH 2 FIGURES)

For the past five years I have been engaged in an intensive study of the Michigan species of *Clitocybe*. This project was undertaken to provide a basis for a revision of the North American taxa.

Since the early accounts by Kauffman (**1918, 1927**), over a thousand collections of *Clitocybe* have been made within the state, chiefly by A. H. Smith, and, more recently, by myself. The examination of this material has revealed several species and varieties which are undescribed.

The color names within parentheses in the following descriptions are from Ridgway (**1912**).

Clitocybe aeruginosa sp. nov.

Pileus (1.5–)4–8 cm latus, planus, fibrillosus mox glaber, hygrophanus vel subhygrophanus, griseo-viridis vel aeruginosus, demum pallescens; odor et sapor nulli; lamellae decurrentes, confertae, angustae, albidae demum sordide cremeae; stipes 3–5 cm longus, apice 3–12 mm crasso, farctus vel cavus, primum fibrilloso-striatus tum glaber, albidus; sporae 6–8.5 × 3.5–5 μ, albae.

Specimen typicum legit A. H. Smith, n. 18385, Waterloo, Washtenaw Co., Michigan, July 12, 1942; in Herb. Univ. Mich. conservatum.

Pileus (1.5–)4–8 cm broad, plane with the margin narrowly inrolled and decurved at first, often remaining inrolled for some time, occasionally sulcate-striate, disc becoming shallowly depressed or somewhat gibbous, surface moist, hygrophanous or subhygrophanous, radiate-fibrillose at first with the margin fibrillose-scaly, soon becoming glabrous, color grayish-green ("tea green" to "mineral gray"), often sordid and the disc becoming brownish, fading to "light olive gray" and finally pallid ("tilleul buff"); flesh rather thick on the disc, firm, greenish gray near the surface and pallid below, odor and taste not distinctive.

Lamellae short-decurrent (usually evenly), close, thin, narrow (up to 4 mm), forked at times, often intervenose, whitish at first ("pale

[1] Paper from the Herbarium, Biological Station, and the Department of Botany, University of Michigan, Ann Arbor, Michigan.

[2] Present address: Department of Botany, University of Massachusetts, Amherst, Massachusetts.

pinkish buff"), becoming a sordid cream color, edges even and straight at first, becoming somewhat undulate and cracked or eroded in age.

Stipe 3–5 cm long, 3–12 mm at the apex, equal or enlarged at either end, the base white-tomentose and often embedded in the surrounding leaves, curved at times, solid-stuffed (whitish on the inside), becoming hollow at times, surface fibrillose-striate at first becoming glabrous in age, the apex often somewhat scabrous, usually central, whitish becoming sordid below in age or with bruising.

Spores 6–8.5 × 3.5–5 μ, elliptical, smooth, hyaline to faintly yellowish in KOH, not amyloid, white in mass; basidia 16–30 × 4.5–7 μ, 4-spored; cystidia not differentiated; gill trama regular; pileus tissue: cuticular hyphae cylindrical, 2–3.5 μ in diameter, tramal hyphae mostly cylindical, 4.5–10(–16.5) μ in diameter, clamp connections present.

Solitary or gregarious, on leaves under hardwoods or along sandy roadsides in hardwoods, July to September. Material examined: H. E. Bigelow 2691; A. H. Smith 18385 (TYPE), 18413, 18519, 18561, 18584, 18613, 18643.

Green pigmentation is rare in *Clitocybe*. Other than *C. acruginosa* the only species known to have this color of pileus is *C. odora* (Fr.) Kummer. *C. odora* differs from *C. acruginosa* by a distinctive anise odor and a pinkish buff spore deposit.

Clitocybe brevipes sp. nov.

Pileus 1–2.5 cm latus, planus mox depressus, demum infundibuliformis, primum canus tum glaber, brunnescens, non striatus, hygrophanus, dein incarnatus; lamellae adnatae vel adnexae, demum decurrentes, angustae, confertae, pallentes vel pallido-vinaceae; stipes 1–3 cm longus, apice 2.5–3.5 mm crassus, cavus, lento-fibrosus, aliquanto sericeus mox glaber, pileo vel lamellae concolor; sporae 4–5 × 2.5–3.5 μ, pallido-alutaceae.

Specimen typicum legit A. H. Smith, n. 43123, Wilderness Park, Emmet Co., Michigan, September 22, 1953; in Herb. Univ. Mich. conservatum.

Pileus 1–2.5 cm broad, plane with an incurved margin, soon plano-depressed and finally broadly infundibuliform, not striate, surface covered with a hoary-silky grayish coating of fibrils but soon becoming glabrous, opaque at all times, hygrophanous, ground color brownish ("Verona brown" or near it), gradually fading to pinkish (near "pale cinnamon pink"), often zonate in process of fading; flesh soft and fairly thick, concolorous with surface of pileus, odor and taste not distinctive.

Lamellae adnate to adnexed when young, becoming short-decurrent, narrow, close, thin, forked, intervenose, pallid to watery pallid vinaceous-fawn, edges even and somewhat undulate.

Stipe 1–3 cm long, 2.5–3.5 mm thick at the apex, equal or the base enlarged, base with whitish tomentum, hollow, tough-fibrous, central,

surface more or less silky at first but soon becoming naked, rather moist, nearly concolorous with gills or intermediate in color between gills and cap.

Spores 4–5 × 2.5–3.5 μ, short-elliptical, smooth, hyaline in KOH, not amyloid, pinkish (near pale "pinkish buff") in mass; basidia 13–20 × 3–5 μ, 4-spored; cystidia not differentiated; gill trama regular; pileus tissue: cuticle subgelatinous in KOH, hyphae cylindrical, 1.5–4 μ in diameter, tramal hyphae cylindrical to somewhat inflated, 4.5–13 μ in diameter, clamp connections present.

Gregarious, among lichens in open places, September. Material examined: A. H. Smith 43123 (TYPE), 43124, 43125, 43417.

Few Clitocybes are found growing on lichens. *C. peltigerina* (Peck) Sacc. has been described as occurring in such a habitat, but is a fragile, smaller species than *C. brevipes*, with spores 6.5–8.5 × 4–6 μ.

The habit, spore size, color of spore deposit, and color of pileus will readily separate *C. brevipes* from other hygrophanous species with pallid gills.

Clitocybe distantifolia sp. nov.

Pileus 15–25 mm latus, plano-depressus, glaber, aquoso-avellaneus, striatus, aliquanto plicatus vel undulatus, hygrophanus, demum albidus et opacus; caro tenuissima, flaccida; lamellae decurrentes, distantissimae, angustissimae, intervenosae, tenues, pileo concolores; stipes 2–2.5 cm longus, 2 mm crassus, aequalis, albido-pubescens deorsum, apex glaber, pileo concolor; sporae (5–)6–8 × 3–4.5 μ.

Specimen typicum legit A. H. Smith, n. 1317, Silver Lake, Livingston Co., Michigan, June 11, 1935; in Herb. Univ. Mich. conservatum.

Pileus 15–25 mm broad, plane to broadly depressed, margin striate becoming somewhat plicate to undulate, very thin and flaccid, surface glabrous, hygrophanous, color a pale watery gray when fresh (avellaneous), fading to whitish; flesh very thin, flaccid, concolorous with pileus surface, odor and taste not distinctive.

Lamellae decurrent (usually evenly), distant, often forked, intervenose, very narrow, thin, concolorous with the pileus, edges even and straight.

Stipe 2–2.5 cm long, 2 mm thick at apex, equal, central, terete, surface whitish pubescent except for apex (about $\frac{1}{3}$ of length), basal tomentum absent, concolorous with pileus beneath the pubescence.

Spores (5–)6–8 × 3–4.5 μ, elliptical, smooth, hyaline in KOH, not amyloid, color of deposit not known; basidia 23–30 × 4–6.5 μ, 2- or 4-spored; cystidia not differentiated; gill trama interwoven, subhymenium rather thick and cellular; pileus tissue: cuticular hyphae encrusted, walls slightly thickened, brown in KOH, cylindrical to somewhat inflated, 6–10 μ in diameter, tramal hyphae cylindrical, usually thin-walled and not encrusted, 3–6 μ in diameter, clamp connections present.

Solitary or scattered, on mossy bark at base of tree, June and July. Material examined: A. H. Smith 1317 (TYPE), 1351.

This species is similar in appearance to the pale forms of **Clitocybe epichysium** (Fr.) comb. nov.,[3] but it can be distinguished by the extremely narrow, distant, forked gills. The gills are somewhat like those found in the genus *Cantharellus*, but the basidia are typical of *Clitocybe*.

CLITOCYBE GERARDIANA (Pk.) Sacc. var. **fusca** var. nov.

Pileus 1–3 cm latus, convexo-depressus patens, medius squamulosus, margine glaber, fuscus, striatus, hygrophanus, demum pallescens et opacus; caro mollis; lamellae decurrentes, latae, subdistantes, griseo-brunneae; stipes 1–3 cm longus, 1–3 mm crassus, cavus, udus, undulatus, sursum glaber, pileo concolor, albido-pubescens deorsum; sporae (7–)8.5–12 × 3–4.5 μ.

Specimen typicum legit A. H. Smith, n. 42574, Pike Lake, Luce Co., Michigan, September 11, 1953; in Herb. Univ. Mich. conservatum.

Pileus 1–3 cm broad, convex-depressed at first, expanding to shallowly infundibuliform, surface squamulose about the depression, glabrous or nearly so toward the margin, hygrophanous, color dark brown ("fuscous" to "mummy brown") when moist, at maturity bister between the conspicuous dark translucent striae, paler and opaque when faded; flesh thin and soft, concolorous with the pileus, odor and taste not distinct.

Lamellae long-decurrent, subdistant, broad, intervenose, rarely forked, thin, color grayish-brown ("drab" or "hair brown"), scarcely paler in age, edges even and often darker grayish-brown, somewhat undulate.

Stipe 1–3 cm long, 1–3 mm thick at the apex, equal or nearly so, undulate, moist, hollow, glabrous near the apex, concolorous with the pileus, whitish pubescent where attached to the sphagnum.

Spores (7–)8.5–12 × 3–4.5 μ, narrowly elliptical to subcylindrical in face view, inequilateral from the side, smooth, hyaline in KOH, not amyloid, color of deposit not known; basidia 23–33 × 5–8.5 μ, four-spored; cystidia not differentiated; gill trama interwoven, hyphae encrusted at times; pileus tissue: cuticle dark brown in KOH, hyphae encrusted, trama paler, hyphae encrusted at times, cylindrical to inflated, (2–)6–10(–14) μ in diameter, clamp connections present.

Scattered, on sphagnum in bogs. Known only from the type collection.

C. gerardiana var. *fusca* is similar to var. *gerardiana* in microscopic characters and habitat, but is distinctive in the dark brown color, broad gills, and so far has been found only in the fall.

[3] *Agaricus epichysium* Fries, Syst. Myc. 1: 169. 1821.

The carpophores of **Clitocybe icmadophila** (Fr.) comb. nov.[4] are also dark brown and may occur on sphagnum. This species is easily distinguished from *C. gerardiana* var. *fusca* by the glabrous pileus and spores 6–8.5 × 4–6 μ. *C. icmadophila* was first reported in Michigan by A. H. Smith (**1936**) as forms II and III of *Omphalia epichysium* Fr.

Variety *gerardiana* cannot be considered identical with *Agaricus sphagnicola* Berk., as some European investigators have claimed. Berkeley (**1836**) emphasizes that *A. sphagnicola* has a "tough and elastic nature." The carpophores of both varieties of *C. gerardiana* are always soft and fragile. *Agaricus philonotis* Lasch is also different for it is described as having a membranous texture.

Clitocybe incisa sp. nov. FIG. 1.

Pileus 2–8 cm latus, convexus mox planus, margine demum elatus et arcuatus, raro incisus, udus sed non hygrophanus, fibrillosus, primum brunneus, tum cinnamomeus vel alutaceus; odor et sapor farinacei; lamellae adnatae demum decurrentes, confertae vel subdistantes, latae, albidae dein stramineae; stipes 4–6 cm longus, 6–20 mm crassus, solidus, fibrillosus, pileo concolor vel pallidior; sporae (6.5–)8–10 × 4.5–6.5 μ, albae.

Specimen typicum legit H. E. Bigelow, n. 502, prope Ann Arbor, Michigan, May 25, 1952; in Herb. Univ. Mich. conservatum.

Pileus (2–)4–8 cm broad, convex at first soon becoming plane, the disc gibbous or sharply depressed at times, margin becoming arched or irregularly elevated in age, split at times, not striate, surface moist but not truly hygrophanous, opaque, with a thin hoary-fibrillose coating at first, finally fibrillose only at the margin and diffracted-scaly on the disc, somewhat roughened at times, color brown ("sayal brown," "snuff brown," "chestnut brown," "Rood's brown"), becoming a dull "cinnamon" or "light pinkish cinnamon," finally fading to buff in age ("pinkish buff" on the disc to alutaceous near the margin); flesh thick on the disc, rather tough and fibrous, color sordid watery-cinnamon at first, finally slightly brownish near the cuticle and whitish below, odor and taste farinaceous.

Lamellae broadly adnate at first soon becoming short-decurrent, finally moderately decurrent (unevenly), intervenose, occasionally forked, close to subdistant, broad (up to 7 mm), rufous tinted when young then whitish to buff, edges even to slightly eroded, somewhat undulate.

Stipe 4–6 cm long, (0.6–)1–2 cm thick at the apex, equal at first then the apex enlarged, solid (whitish inside), central, surface with a thin coating of fibrils which soon become arranged in patches, finally

[4] *Agaricus epichysium* β *icmadophilus* Fries, Syst. Myc. 1: 169. 1821.

FIG. 1. *Clitocybe incisa*, ×1.

glabrous or fibrillose-striate, cortex splitting in age, concolorous with the pileus or paler, base usually with a few conspicuous rhizomorphs.

Spores (6.5–)8–10 × 4.5–6.5 μ, elliptical to oboval, smooth, hyaline to faintly yellowish in KOH, not amyloid, white in mass; basidia (20–)25–46 × 4.5–8(–10)μ, 2- or 4-spored; cystidia not differentiated; gill trama regular; pileus tissue: cuticle brownish in KOH, some hyphae encrusted, cylindrical, 2–8 μ in diameter, trama thick and often floccose, hyaline, hyphae mostly cylindrical, 3–8(–13)μ in diameter, clamp connections present.

Solitary to scattered on soil in grass, on lawns or road shoulders, May and June. Material examined: H. E. Bigelow 502 (TYPE), 814, 1606, 2407, 2925; A. H. Smith 18939.

Clitocybe incisa is similar to *C. praecox* Kauffman, for both species have a strong farinaceous odor and taste, occur in the spring in grassy areas, and are brownish in color. However, the pileus of *C. praecox* remains plane with an even margin. The surface is conspicuously scaly and dry, as well as darkening at maturity. In addition the gills are less decurrent and narrower than those of *C. incisa*.

C. sinopica (Fr.) Kummer is similar in odor and taste and spore size, but differs from *C. incisa* by virtue of the reddish-brown colors, slender stipe, and creamy to yellowish spore deposit.

Clitocybe insipida sp. nov.

Pileus 3–5 cm latus, planus, glaber, pallide luteus, hygrophanus, demum fibrillosus et luteo-alutaceus; lamellae decurrentes, confertae, angustae, albidae, demum pallide luteo-alutaceae vel cremeae; stipes 3–5 cm longus, apice 5–8 mm crasso, farctus dein cavus, fibrillosus, albidus; sporae 6–8 × 3.5–5 μ, leves, pseudoamyloideae.

Specimen typicum legit A. H. Smith, n. 43134, Wilderness Park, Emmet Co., Michigan, September 22, 1953; in Herb. Univ. Mich. conservatum.

Pileus 3–5 cm broad, plane with the margin inrolled and incurved, remaining plane or becoming shallowly depressed, surface hygrophanous, glabrous when moist, appearing matted-fibrillose faded, soft to the touch, irregularly rivulose in age at times, color a pale butterscotch when moist, fading to pinkish buff or dingier; flesh thick on the disc and soft, whitish, odor and taste not distinctive.

Lamellae moderately decurrent to long-decurrent (evenly), usually forming a collar on the stipe, close, narrow, often intervenose, at times the interspaces becoming perforated in drying, occasionally forked, whitish at first becoming pale pinkish buff or more cream color, edges even, straight or slightly undulate.

Stipe 3–5 cm long, 5–8 mm thick at the apex, equal or enlarged at the base, base tomentose and somewhat embedded in the surrounding needles, central, terete above the enlarged base, solid-stuffed becoming hollow, surface matted white-fibrillose, becoming ochraceous in places in age.

Spores 6–8 × 3.5–5 μ, elliptical, smooth, hyaline in KOH, yellow-brown in Melzer's, thin-walled, pinkish buff to yellowish in mass; basidia 26–44 × 4.5–8 μ, usually 4-spored, occasionally 2-spored; cystidia not differentiated; gill trama regular; pileus tissue: cuticle of cylindrical hyphae, 1.5–4 μ in diameter, trama of mostly cylindrical hyphae, 3–9 μ in diameter, clamp connections present.

Gregarious under conifers. Known only from the type collection.

The pseudoamyloid spores of *Clitocybe insipida* distinguish it from all species but *C. aurantiaca* (Fr.) Studer. The latter is easily separated by the orangish colors and the obtuse, dichotomously forked gills.

Clitocybe pallescens sp. nov.

Pileus 1.5–3 cm latus, plano-depressus demum infundibuliformis, glaber, aquoso-griseus et striatus, hygrophanus, demum albidus et opacus, sericeus siccus; lamellae decurrentes, confertae vel subdistantes, angustae vel latae, albidae; stipes 3–5 cm longus, apice 2–4 mm crasso, albido-farctus, nonnumquam rimosus vel lineatus, griseo-albidus vel pallidior; sporae 5–7 × 3–4 μ; cheilocystidia irregulariter obtusa vel fusoidea.

Specimen typicum legit A. H. Smith, n. 1445, Livingston Co., Michigan, July 1, 1935; in Herb. Univ. Mich. conservatum.

Pileus 1.5–3 cm broad, plano-depressed to broadly infundibuliform, margin elevated in age and wavy or lobed, surface glabrous, hygrophanous, pale watery gray and striate when moist, opaque and whitish when faded, appearing silky when dry; flesh thin, rather cartilaginous, concolorous with the surface, odor and taste mild.

Lamellae decurrent, close to subdistant, narrow to moderately broad, intervenose, forked, arched at first, dull white, edges even and undulate.

Stipe 3–5 cm long, 2–4 mm thick at the apex, equal or the base slightly enlarged, central, stuffed by a white pith, surface with occasional appressed white streaks or cracks, dull grayish white or paler.

Spores 5–7 × 3–4 μ, elliptical, smooth, hyaline to faintly yellowish in KOH, not amyloid, color of deposit unknown; basidia ±25 × 6 μ, 1-, 2-, 3- or 4-spored; cheilocystidia present, irregularly obtuse or fusoid, smooth, thin-walled, ± 50 × 10 μ, about half the length usually protruding beyond the hymenium; gill trama nearly parallel; pileus tissue: hyaline in KOH, homogeneous, hyphae cylindrical to inflated, 7–25 μ in diameter, clamp connections present.

Gregarious, on wood at base of a living ash tree. Known only from the type collection.

The cheilocystidia and the lignicolous habit are characters which will separate *C. pallescens* from other hygrophanous gray Clitocybes. The presence of the obtuse or fusoid type of cystidia is very rare in *Clitocybe*, and is a distinctive diagnostic character.

Clitocybe rancida sp. nov.

Pileus 7–15 mm latus, planus, demum depressus, raro infundibuliformis, glaber, striatus et saepe sulcatus, avellaneus, hygrophanus, demum cinereus et canus; odor et sapor rancido-farinacei; lamellae decurrentes, subdistantes, angustae vel latae, udo pileo concolores; stipes 2–3.5 cm longus, 1–1.5(–2) mm crassus, paene aequalis, glaber, lamellis sursum concolor, deorsum nigrescens; sporae 5–8(–10) × 3.5–5 μ.

Specimen typicum legit A. H. Smith, n. 43457, Wilderness Park, Emmet Co., Michigan, September 28, 1953; in Herb. Univ. Mich. conservatum.

Pileus 7–15 mm broad, plane with the margin incurved and decurved at first, becoming plano-depressed or more rarely broadly vase-shaped, margin translucent-striate and often sulcate when moist, surface glabrous, hygrophanous, appearing hoary when fading, color dark avellaneous ("drab"), fading on the disc first to cinereous; flesh membranous, soft, watery gray, thin, odor and taste rancid-farinaceous.

Lamellae short-decurrent (unevenly), subdistant, narrow to moderately broad, intervenose, rarely forked, arched, color "drab," edges even and straight.

Stipe 2–3.5 cm long, 1–1.5(–2) mm thick at the apex, slightly narrowed downward, glabrous, central, concolorous with the gills at the apex, blackening at the base and gradually upward.

Spores 5–8(–10) × 3.5–5 μ, elliptical, smooth, hyaline in KOH, not amyloid, color of deposit unknown; basidia 22–27 × 4–7 μ, mostly 4-spored, rarely 1-spored; cystidia not differentiated; gill trama interwoven, hyphae very finely encrusted at times; pileus tissue: cuticle pale yellow-brown in KOH, walls very finely encrusted, cylindrical, 2–5 μ in diameter, tramal hyphae cylindrical to inflated, 3–17 μ in diameter, not encrusted, clamp connections present, scattered thick-walled refractive hyphae, cylindrical, flexuous, ± 3 μ in diameter.

Gregarious, around sedges at edge of beach pool. Known only from the type collection.

Several other Clitocybes with darkening or blackening stipes have been described, namely *C. fuligineipes* Métrod, *C. fritilliformis* Fr. ss. Ricken, *C. dicolor* Lange, *C. pausiaca* ss. Kühner and Romagnesi. All are considerably larger and fleshier, occurring under conifers on needle beds.

Clitocybe rubella sp. nov.

Pileus 1–2.5 cm latus, primum obtuso-conicus tum planus, siccus, rubellus, demum pallidior; odore nullo, sapore amaro; lamellae decurrentes, confertae vel confertissimae, angustae, albae; stipes 2–4 cm longus, 2–4 mm crassus, aequalis, farctus demum cavus, glaber, albidus, basi oriente e massa plectenchymatica; sporae 5–6.5 × 4–4.5 μ.

Specimen typicum legit A. H. Smith, n. 9603, Milford, Oakland Co., Michigan, July 13, 1938; in Herb. Univ. Mich. conservatum.

Pileus 1–2.5 cm broad, obtusely conic at first becoming plane or nearly so, margin arched at times, not striate, surface dry, minutely fibrillose to furfuraceous under a lens, color pinkish tan ("onion skin pink" or "pecan brown") at first, becoming paler and fading to "light pinkish cinnamon" near the margin; flesh thick on disc, thin at the margin, whitish, taste bitterish, odor none.

Lamellae short-decurrent at first, finally long-decurrent (unevenly), close to crowded, narrow, thin, occasionally forked, not intervenose, white, edges even and straight.

Stipe 2–4 cm long, 2–4 mm thick at the apex, equal, whitish-stuffed, becoming hollow in age, surface glabrous, whitish, base arising from a whitish soft-fleshy convoluted mass of tissue.

Spores 5–6.5 × 4–4.5 μ, elliptical to oboval, smooth, hyaline in KOH, not amyloid, color of deposit unknown; basidia 20–30 × 4–6 μ, 2- or 4-spored; cystidia not differentiated; gill trama interwoven; pileus tissue: cuticle pale yellow-brown in KOH, some hyphae finely encrusted, trama hyaline, hyphae mostly cylindrical, walls usually thin, 3–7 μ in diameter, clamp connections present; sclerotial tissue: hyphae cylindrical to inflated, 2–11 μ in diameter, some with finely encrusted, thin or slightly thickened walls, clamp connections present.

Gregarious to cespitose on sandy soil. Known only from the type collection.

Clitocybe rubella is described as new because of the sclerotial mass at the base of the stipes. The only other species in the genus with this structure is **Clitocybe sclerotoidea** (Morse)[5] comb. nov. from the Pacific Northwest. This has a whitish pileus, sordid buff gills, and subfusiform spores 8–10 × 3–4 μ.

[5] *Tricholoma sclerotoideum* Morse, Mycologia **35**: 573. 1943.

Clitocybe subcanescens sp. nov. var. **subcanescens.** FIG. 2.

Pileus (1–)2.5–5(–8) cm latus, convexus demum planus, nonnumquam depressus, semper opacus, albido-pruinosus (infra pallide luteus), hygrophanus, ultimo glaber

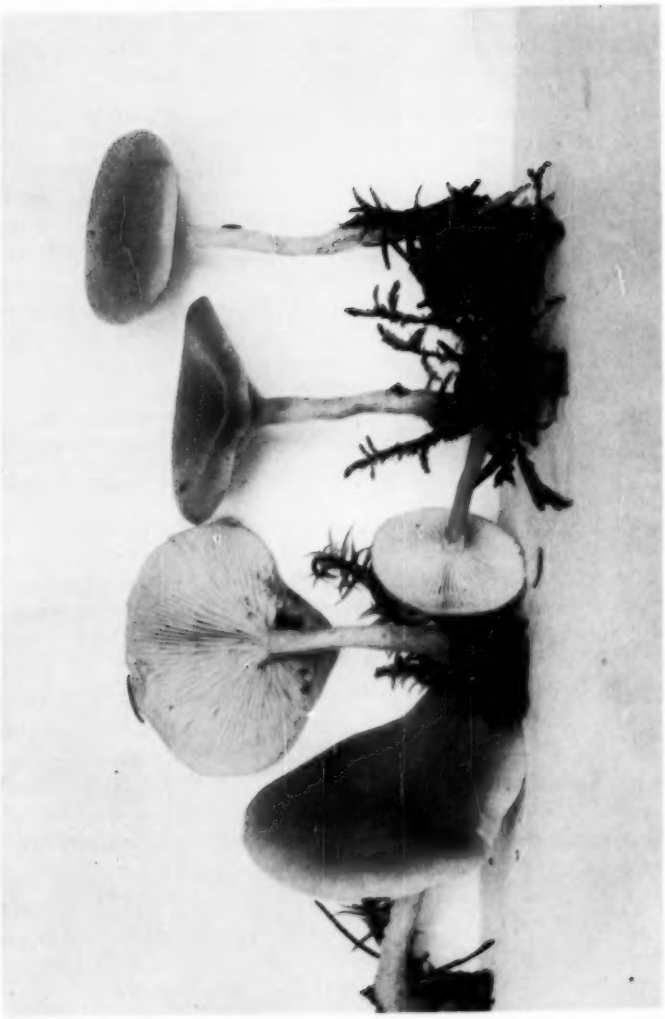


FIG. 2. *Clitocybe subcanescens* var. *subcanescens*, ×1. (Photograph by A. H. Smith.)

et candidus; odor et sapor nulli; lamellae decurrentes, confertae, angustae, albidae vel pallide luteo-alutaceae; stipes 3–5 cm longus, apice 3–6 mm crasso, cavus, fibroso-lentus, albido-pruinosus, demum glaber, dein lamellae concolor; sporae 5–6 × 3–4 μ, pallide roseo-cinnamomeae.

Specimen typicum legit A. H. Smith, n. 43127A, Wilderness Park, Emmet Co., Michigan, September 22, 1953; in Herb. Univ. Mich. conservatum.

Pileus (1–)2.5–5(–8) cm broad, broadly convex-depressed at first or lacking the depression, margin inrolled, not striate, becoming plane and shallowly depressed, margin wavy in age, surface white-hoary with a pale butterscotch ground color, becoming glabrous, slightly rivulose in age, hygrophanous and fading to a dead white, opaque at all times; flesh soft and pliant, concolorous with the surface, odor and taste not distinctive.

Lamellae short-decurrent to moderately decurrent, narrow, crowded to close, forked, intervenose, arched when young, whitish to "pale pinkish buff" (not dingy with maturity), edges even and straight.

Stipe 3–5 cm long, 3–6 mm thick at the apex, equal or the base somewhat enlarged, base with white tomentum, usually central, hollow, curved at times, fibrous-tough, surface whitish-hoary from a canescent covering, becoming slowly glabrescent, more or less concolorous with the gills, not darkening appreciably.

Spores 5–6 × 3–4 μ, elliptical, smooth, hyaline in KOH, not amyloid, pinkish ("pale pinkish cinnamon" or "pinkish buff") in mass; basidia 13–28 × 4–6 μ, 4-spored; cystidia not differentiated; gill trama regular; pileus tissue: cuticular hyphae cylindrical, 2–3.5 μ in diameter, tramal hyphae mostly cylindrical, 3–10 μ in diameter, clamp connections present.

Gregarious, on needle beds under conifers, rarely on sandy soil under aspen, September and October. Material examined: H. E. Bigelow 1569; H. Imshaug 4541; A. H. Smith 21046, 33965, 34027, 36048, 42743, 42786, 43126, 43127A (TYPE), 43127B, 43128, 43135, 43137, 43138, 43162, 43163, 43785, 50873, 50982, 50983, 50984, 50987, 51008, 51092.

The pinkish spore print will conveniently distinguish *C. subcanescens* from most pale hygrophanous species with whitish gills, such as *C. diatreta* (Fr.) Kummer, *C. angustissima* (Fr.) Kummer, and *C. flavidella* (Pk.) Sacc. *C. incarnata* Métrod is described as having pale cream spores, 6.5–7 × 3.5–4 μ, but the pileus is only 2.5 cm broad, "ocracé-incarnat-rosé," and finely striate. Of the species known to have a pinkish spore deposit, probably *C. phyllophila* (Fr.) Kummer is the only one likely to be confused with *C. subcanescens*. However, it is usually larger, fleshier, with a strong fragrant odor, and with broad gills.

Clitocybe subcanescens var. **robusta** var. nov.

Var. *subcanescenti* similis sed pileus obscurus, caro crassa, lamellae primum adnatae, stipes 9–20 mm crassus.

Specimen typicum legit A. H. Smith, n. 43004, Wilderness Park, Emmet Co., Michigan, September 22, 1953; in Herb. Univ. Mich. conservatum.

Variety *robusta* differs from var. *subcanescens* in: pileus 4–8 cm broad, watery brownish when moist; flesh thick; lamellae adnate at first; stipe 9–20 mm thick.

Additional material examined: H. E. Bigelow 2901; A. H. Smith 43133.

Clitocybe subfumosa sp. nov.

Pileus 5–20 mm latus, planus mox depressus, raro infundibuliformis, glaber, fumosus, obscure striatus, hygrophanus, demum pallido-griseus vel albidus, opacus; caro flaccida, odore nullo, sapore farinaceo, lamellae decurrentes, angustissimae, confertissimae, sordide albido-griseae; stipes 1–2.5 cm longus, apice 1.5 mm crasso, flaccidus, fibrillosus vel subpruinosus, fistulosus, pallido-fuligineus demum albidus, basis radiato-strigosus; sporae 4.5–6 × 2.5–3.5 μ.

Specimen typicum legit A. H. Smith, n. 1777, George Reserve, Livingston Co., Michigan, August 10, 1935; in Herb. Univ. Mich. conservatum.

Pileus 5–20 mm broad, plane, soon sharply depressed, margin remaining horizontal or somewhat elevated in age, at times becoming broadly vase-shaped, closely but inconspicuously striatulate when moist, opaque when faded, surface glabrous, hygrophanous, smoky to watery-gray when moist, pallid gray to whitish on the margin, whitish over all when faded; flesh thin, pallid, flaccid, odor none, taste farinaceous.

Lamellae long-decurrent (evenly), very narrow, thin, crowded, arched, forked, intervenose, color a sordid whitish gray, edges even and straight.

Stipe 1–2.5 cm long, 1.5 mm thick at the apex, equal or the apex slightly enlarged, flaccid, not cartilaginous, often curved, surface with scattered fibrils, subpruinose at times, fistulose, pale fuligineous in color becoming pallid in age, base with radiating white hairs.

Spores 4.5–6 × 2.5–3.5 μ, elliptical, smooth, hyaline in KOH, not amyloid, color of deposit unknown; basidia 14–23 × 3–5 μ, 2- or 4-spored; cystidia not differentiated; gill trama regular; pileus tissue: homogeneous, hyphae cylindrical to slightly inflated, 2–11 μ in diameter, clamp connections present.

Gregarious, on wood at the base of an oak tree. Known only from the type collection.

Of the lignicolous Clitocybes, only *C. subbulbipes* Murr. is similar to *C. subfumosa*. The long-decurrent lamellae, sharply depressed pileus, and farinaceous taste distinguish the latter species.

Clitocybe subnitens sp. nov.

Pileus (1.5–)3–7 cm latus, convexus demum planus, non striatus, ultimo elatus, glaber, brunneus, hygrophanus, dein pallide cinnamomeus; caro tenax, odore et sapore ingratis vel aliquantum farinaceis; lamellae adnatae vel sinuatae demum, decurrentes, confertae, latae, primae lutescentes, tum palliide cinnamomeae; stipes 1.5–4 cm longus, apice 5–15 mm crasso, deorsum subattenuatus, solidus demum cavus, glaber dein fibrilloso-striatus, paene concolor pileo; sporae 4–6 × 2–3 μ, pallide cremeae.

Specimen typicum legit H. E. Bigelow, n. 1468, Waugochance Point, Emmet Co., Michigan, August 30, 1953; in Herb. Univ. Mich. conservatum.

Pileus (1.5–)3–7 cm broad, convex at first with the margin inrolled, becoming plane with the disc shallowly depressed, at times umbilicate to gibbous or umbonate, margin becoming elevated in age and often undulate or sinuate, not striate, surface glabrous, hygrophanous, color brown ("sayal brown," "verona brown," "brussels brown," "buckthorn brown" or "cinnamon brown") when moist, paler when faded ("clay color," "tawny olive" or "cinnamon buff"); flesh thick, firm and tough, watery buff fading to whitish, odor and taste disagreeable to somewhat farinaceous.

Lamellae adnate by a tooth or sinuate at first, becoming short-decurrent (evenly), posterior ends forming a collar on the stipe, crowded to close, broad but attenuated at both ends, not forked, not appreciably intervenose, brittle, color buff at first ("warm buff" to "ochraceous buff"), darkening to brownish ("cinnamon buff," "clay color," "snuff brown").

Stipe 1.5–4 cm long, 5–15 mm thick at the apex, enlarged at the apex and tapering downward, base white-mycelioid and somewhat embedded in the surrounding needles, usually central, compressed or fluted at times, solid at first becoming hollow in age (the interior watery buff to brownish, fading to whitish), surface appearing glabrous when moist, the apex matted-fibrillose when faded, fibrillose-striate below, near concolorous with the pileus ("tawny olive" at the apex, "cinnamon brown" at the base, hygrophanous, fading to near "clay color" or "cinnamon buff").

Spores 4–6 × 2–3 μ, narrowly elliptical, smooth, hyaline in KOH, not amyloid, faintly cream colored in mass; basidia 16.5–27 × 4–6 μ, 2- or 4-spored; cystidia not differentiated; gill trama regular to subparallel; pileus tissue: cuticle pale yellow-brown in KOH, pigment in cell sap of cylindrical hyphae, 2–3 μ in diameter, tramal hyphae mostly cylindrical, 2–8.5 μ in diameter, hyaline, clamp connections present.

Gregarious to cespitose under spruce, August and September. Material examined: H. E. Bigelow 1468 (TYPE), 1519, 1583; A. H. Smith 43462.

The relationships of *C. subnitens* are difficult to determine. In such characters as color, thickness of flesh, odor and taste, it is close to *C. sinopica* (Fr.) Kummer and related species. On the other hand, the hygrophanous pileus and darkening lamellae indicate affinities with *C. umbilicata* f. *spadicea* (Lange). The taxonomic position of *C. subnitens* is uncertain at present, but the field characteristics and microscopic ones form a distinctive combination.

ACKNOWLEDGMENTS

I wish to express my appreciation to Dr. Alexander H. Smith, under whose direction this investigation was made, for his suggestions and criticisms as well as for turning over his collections and field data to me for use in this study. I am also grateful to Dr. E. B. Mains and Dr. B. B. Kanouse of the University of Michigan Herbarium for the loan of specimens, and to Dr. A. H. Stockard of the University of Michigan Biological Station for the use of the station facilities during the summers of 1952, 1953, and 1955.

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DEPARTMENT OF BOTANY
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

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THREE NEW SPECIES OF MYXOMYCETES FROM GREECE

CONST. J. ALEXOPOULOS

(WITH 5 FIGURES)

The three new species of Myxomycetes described below developed in moist chamber culture on bark taken from living trees during my sojourn in Greece on a Fulbright Fellowship from September 1954 to August 1955. The technique described by Gilbert and Martin (**4**) which I have used before with good results (**1**, **2**, **3**) was employed in these studies.

Echinostelium elachiston sp. nov. FIG. 1

Sporangia solitaria vel gregaria, ad 0.15 mm alta, 40–50 μ diam., erecta vel nutantia, aurea ad pallida, stipitata; stipes brevis, erectus, 60 vel 90 μ altus; peridium transparens, fugax, nonnunquam reliquens collare ad apicem stipitis; capillitium absens; sporae globosae leves, aureae, vel pallidae, 6.5–8 μ diam.

Sporangia scattered or gregarious, total height 0.12–0.15 mm, globose, 40–50 μ diam., erect or nodding, golden yellow, sometimes fading to cream color; stipe hairlike, golden brown, darker toward the base, expanded below, its surface rough near the apex, 60–95 μ long; peridium very thin, transparent, usually evanescent at a very early stage, leaving a definite collar attached to the tip of the stipe; columella absent or if present, minute, conical; capillitium absent; spores globose, typically golden yellow, smooth, but with well-marked thin places on the wall, 6.5–8 μ in diameter, easily dispersed as a mass which clings together, or individually; plasmodium unknown.

Type (GR-194) developed in moist chamber culture on bark collected October 13, 1954, from living *Platanus orientalis* growing by the banks on the Peinios River in the Valley of Tempe, Thessaly, Greece. Other moist chamber developments: Nos. GR-213, 250, on bark of *Juniperus phoenicia,* Astypalaia island, January 1955; No. GR-228, on bark of *Cupressus sempervirens,* Marathon, Attica, March 19, 1955; No. GR-229, on bark of *Acer negundo,* Olympia, Elis, April 15, 1955; No. GR-237, on bark of *Ceratonia siliqua,* Mesagros, Aegina island, September 5, 1955; No. GR-249, on bark of *Olea europea,* Thasos island, Oct. 26, 1954; No. GR-252, on bark of *Olea europea,* Porto Germano, Attica, March 31, 1956.

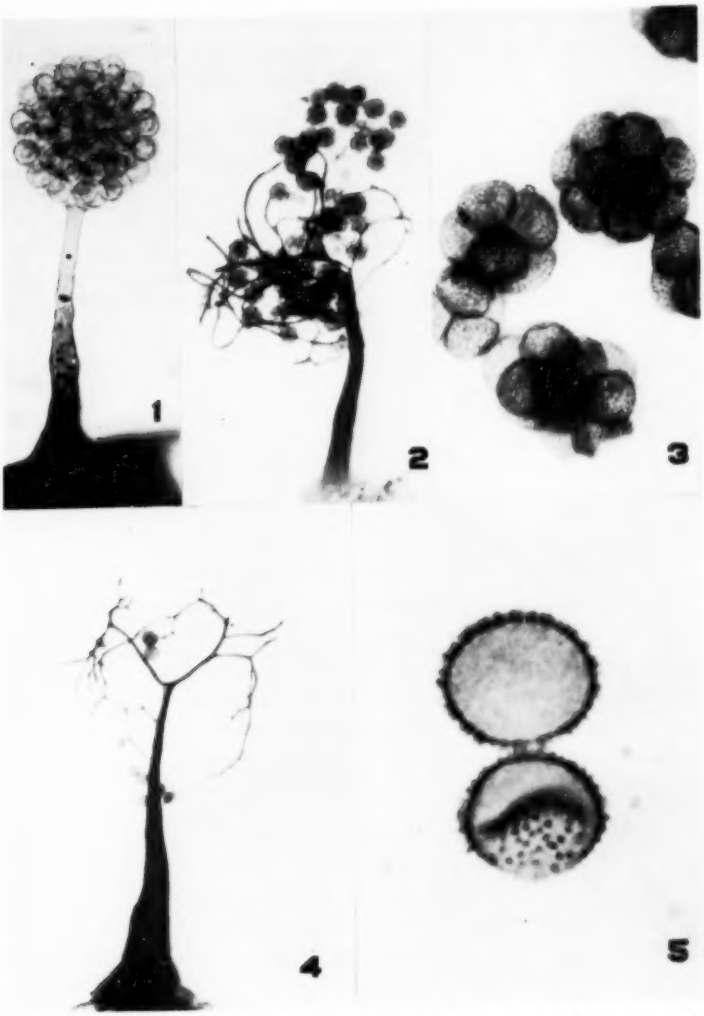

FIG. 1. *Echinostelium clachiston.* Sporangium showing peridial collar, × 460. FIGS. 2–3. *Comatricha synsporos.* 2. Entire sporangium, × 170. 3. Spore clusters, × 910. FIGS. 4–5. *Comatricha acanthodes.* 4. Sporangium with spores removed to show scanty capillitium, × 150. 5. Two spores showing prominent spines, × 1700. All figures are prints from 35 mm Kodachrome transparencies.

Type deposited in the Mycological Collection of the State University of Iowa, Iowa City, Iowa. Other material deposited in the Farlow Herbarium and the Commonwealth Mycological Institute. Etymol. ἐλάχιστον smallest.

Apparently widely distributed in Greece, this minute species appears in two distinct forms. The material designated as Type exhibits a peridial collar and a minute, conical columella, and disperses all its spores at maturity. The more common form, however, lacks a peridial collar and columella and possibly, in fact, never forms a peridium. Upon maturity, this form disperses all its spores but one which clings tenaciously to the tip of the stipe as if fused with it. Intermediate forms occur, but appear to be rare.

This is now the smallest of the known Myxogastres. It differs from *E. minutum*, the only other known species of the genus, in the size of the sporangia, the color of the spores, and the complete absence of capillitium. It develops rapidly, sometimes within 24 hours, from the time the bark is wet. When the sporangia are mature it is almost impossible to mount.

Comatricha synsporos sp. nov. FIGS. 2, 3

Sporangia solitaria, brunnea, globosa, stipitata, minuta 0.25 mm diam., 0.35–0.5 mm alta; stipes ater, gracilis, ad basim latior, in sporangium tamquam columella penetrans et ad centrum attingens; capillitium ex apice et lateribus columellae enascens, ramificiens et reticulum globosum peridiale cum terminis liberis formans; peridium plane fugax; sporae fuscae, pyriformae, in fasciculis densis inter se adhaerentes, supra verrucosae, alibi leves, 9.5–10.5 μ diam.

Sporangia scattered or solitary, dark brown, globose, stipitate, minute, 0.25 mm diam., their total height 0.35 to 9.5 mm; peridium completely evanescent; stalk black, slender, straight, slightly tapering upward and continuing into the middle of the sporangium as a columella; capillitium lax, arising from the tip and sides of the columella, branching and anastomosing, forming a globose peridial net with some free ends; spores in compact clusters of 7 to 15, brown, coarsely warted on the exposed area, smooth elsewhere, pyriform; spore clusters 19–26 μ diam.; spores 9.5–10.5 μ diam.

Type (GR-225) developed in moist chamber culture on bark of *Ceratonia siliqua* collected on April 3, 1955, on the island of Rhodes, locality Petalouthes. Type, consisting of four sporangia, deposited in the Mycological Collection of the State University of Iowa, Iowa City.

Etymol. σύν, together, σπορά, seed, spore.

This is the only Comatricha known with spores that adhere in clusters. This species is so different from any other known Comatricha that, in spite of the very scanty material available, I do not hesitate to describe it as new.

Comatricha acanthodes sp. nov. FIGS. 4, 5

Sporangia solitaria, brunnea, globosa vel hemispherica, infra plana, minuta, 0.2 mm diam., 0.4–0.5 mm alta; peridium plane fugax; stipes gracilis, ex hypothallo discoideo, rubrobrunneo, tenuissimo enascens, in sporangium tamquam columella penetrans et ad centrum attingens; capillitium ex apice columellae enascens, e 2 aut 4 ramis tenuibus, furcatis, brunneis consistens; sporae globosae, cinereae, spinas prominentes ferentes, 12–16 μ diam.

Sporangia solitary, dark brown, globose or hemispherical, flattened below, minute 0.2 mm diam., their total height 0.4–0.5 mm, peridium completely evanescent; stalk slender, arising from a discoid, reddish brown, very thin hypothallus, tapering upward and continuing to the middle of the sporangium as a columella; capillitium very lax, consisting of generally two, sometimes three slender, black branches arising from the tip of the columella and forking three or four times without anastomoses; spores brown in mass, gray by transmitted light, globose, 12–20 μ in diameter, prominently spiny, the spines as much as 1 μ long.

Type (GR-203) developed in moist chamber culture on bark of cultivated *Olea europea* collected on the island of Thasos on October 26, 1954; deposited in the Mycological Collections of the State University of Iowa. The type consisted of 7 sporangia, six of which have been mounted in lacto-phenol on slides and sealed.

Etymol. "ακανθα, thorn.

This species belongs to the group of the minute Comatrichas with globose sporangia, brown spores, and lax, open capillitium to which *C. cornea, C. fimbriata,* and *C. martinii* (2) belong. It differs from all three in the size of its spores and the very prominent spines thereon.

I wish to express my appreciation to the administrative authorities of Michigan State University for granting me a leave of absence to accept a Fulbright Research Fellowship in 1954–1955, to Professor Jean Politis of the University of Athens for placing the facilities of his laboratory at my disposal, to Dr. O. E. Nybakken of the Department of Classics, State University of Iowa, for correcting the Latin diagnoses, and to Dr. G. W. Martin for valuable advice.

DEPARTMENT OF BOTANY
STATE UNIVERSITY OF IOWA
IOWA CITY, IOWA

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NOTES ON BOLETES. X. A FEW MISCELLANEOUS DISCUSSIONS AND A NEW SUBSPECIES

WALTER H. SNELL AND ESTHER A. DICK

(WITH 1 FIGURE)

AN ORPHAN OF THE TAXONOMIC STORM

When some years ago the junior author found some specimens which appeared to be quite different from *Boletinus castanellus* Pk. in several characters, we named it *B. squarrosoides*. Over succeeding years, we found more material that we considered to be this species, but few collections manifested the extreme differences of the original specimens from *B. castanellus* and many tended toward what we considered typical of the older species. Consequently, when Singer suggested the reduction of *B. squarrosoides* to synonymy, the change appeared to be reasonable.

When Singer was working out a revised system of the boleti, he found that the Friesian-Peckian conception of the genus *Boletinus* was neither workable nor taxonomically logical, and he placed *B. castanellus* in the genus *Gyrodon* (**3**, pp. 171–172)—incidentally, with *squarrosoides* in *Phylloporus* (**3**, p. 170). Later, he stated (**6**, p. 257) that, in addition to *Boletinus castanellus* being hardly a *Boletinus*, no type is preserved and the species has been variously understood as *Gyrodon merulioides* (Schw.) Sing. (long known as *Boletinus porosus* Pk.) or as *Xerocomus squarrosoides* (Snell & Dick) Sing. He therefore discarded Peck's old epithet *castanellus* and for the taxon accepted the epithet *squarrosoides*, without including *castanellus* in his synonymy (**6**, p. 295), which, it may be said however, is not supposed to be complete.

It appears to be true that type specimens of Peck's *Boletinus castanellus* for some time have not been available in Peck's herbarium at Albany, N. Y. On the other hand, the senior author did see the type specimens there about 20 years ago, when Peck's collections were pretty much as Peck left them and before certain rearrangements in classification, mounting, distribution, etc., were made. In any event, whether or not this type material should be turned up, as certain old

material is from time to time being re-located there, Peck's herbarium does contain authentic material of *Boletinus castanellus*.

Consequently, since we are willing, at least in the present state of our knowledge, to accept Singer's judgment with regard to our original *B. squarrosoides*, we feel that the old epithet should be restored, as **Xerocomus castanellus** (Pk.) comb. nov.[1]

THE XEROCOMOIDEAE AND THE BOLETOIDEAE

In Singer's Boletaceae, the fundamental distinction between the subfamilies Xerocomoideae and Boletoideae is the type of hymenophoral trama, the phylloporoid and the boletoid, respectively.[2] Lohwag and Peringer (**2**) were the first to point out this difference, and Singer was the first to use the two types of structure for taxonomic purposes in his key to the genera of the Agaricales in 1939 (**4**, pp. 27, 37, 39, 52, 54, 97, 98).

The two types of trama are as follows: in the phylloporoid type (*Phylloporus* and *Xerocomus*), the hyphae of the laterostratum are only slightly divergent, rather close and hyaline, and the mediostratum is only slightly darker than the laterostratum, if at all so; in the boletoid type (*Phlebopus, Pulveroboletus, Boletus, Xanthoconium, Tylopilus* and *Leccinum*), the trama is truly bilateral-divergent, with the hyphae of the laterostratum strongly divergent, loosely arranged and usually hyaline, and the mediostratum definitely darker than the laterostratum. The characteristic features of these two types of trama are most conspicuous in the hymenophore of young stages, the young tubes near the margin of mature specimens and the younger portions of the older tubes near the stipe. In the older tubes, especially of over-mature or declining specimens, the distinctive characters of each type of trama are inclined to disappear. In age, the phylloporoid type of trama, especially the laterostratum, may be irregular; in the boletoid type, the hyphae of the laterostratum become stretched with growth and then are more or less parallel with the mediostratum.[3] Furthermore, as might be ex-

[1] *Boletinus castanellus* Pk., Bull. Torr. Bot. Club **27**: 613. 1900.
Gyrodon castanellus (Pk.) Sing., Rev. de Myc. **3**: 172. 1938.
Boletinus squarrosoides Snell & Dick, Mycologia **28**: 468. 1936.
Phylloporus squarrosoides (Snell & Dick) Sing., Rev. de Myc. **3**: 170. 1938.
Xerocomus squarrosoides (Snell & Dick) Sing., Farlowia **2**: 295. 1945.

[2] Almost all of the Strobilomycetaceae and of the Boletaceae except the Xerocomoideae possess a boletoid trama, as far as studied, but it is between these two subfamilies that the distinction is of critical and practical importance.

[3] Following the appearance of the paper by Lohwag and Peringer (**2**), two of our students, Elrod and Blanchard, made some studies of the trama of certain

pected, there are species with trama that is definitely neither of one type nor the other, that is more or less intermediate or otherwise variable. Consequently, disposition of these species in one or the other of the subfamilies must be more or less arbitrary or upon other grounds that appear to denote relationship, as Singer has pointed out (**6**, pp. 286–287).

So much for the taxonomic aspects, but what about the practicality of the situation? Even the expert with a certain amount of intuition developed from long experience cannot always be absolutely certain of the distinction between a *Xerocomus* and a *Boletus*, the two genera the most difficult to distinguish, especially when dried even recently, let alone up to 75 years ago. And those not expert in the boleti are inclined to throw up their hands even at the suggestion of determining the type of trama in a fresh specimen.

Several years ago, we and our students began to make observations upon the hymenophore and so-called "tubes" of the boleti, with the object of finding if possible something, anything, that would contribute to the taxonomy of the group or aid in the identification of specimens. None of these studies led to anything of any apparent significance, either for taxonomy or for identification. The most interesting and most important observations were made more recently by the present writers with regard to the make-up of the hymenophores of *Xerocomus* on the one hand and *Boletus*, *Tylopilus* and *Leccinum* on the other. The hymenophore of *Boletus*, etc., is made up of distinct tubelets, individualized and easily separable each one from the others; the hymenophore of *Xerocomus*, on the other hand, has no distinct tubelets, no individual "tubes," but only an arrangement of vertical walls or plates bounding long, vertical cavities or "pseudotubelets," often if not usually compound with vertical plates cutting across the elongated cavities at various levels, the entire arrangement in cross-section appearing as an angular network rather than a fused aggregation of ovals or rings. For purposes of simple and very elementary objective illustration, we thought of the difference in these terms—the hymenophore of *Boletus*, etc., like that of a coalesced bundle of macaroni (*e.g.*, boiled for a short period),

boleti (**1**) and in their material obtained results that did not bear out the conclusions of Lohwag and Peringer. Elrod and Blanchard made no effort to confine their studies to the hymenophores of young stages or the young tubes of older specimens, but used hymenophore material of good carpophores in a vigorous condition, as it appeared that Lohwag and Peringer had done. It would seem possible, if not quite likely, that in many cases at least, Elrod and Blanchard studied material that was too mature to show the differences in the two types of trama, as Singer stated (**6**, p. 286).

each tube an individual entity, the hymenophore of *Xerocomus* like that of a honeycomb. We believe these perhaps crude illustrations accurately represent the differences between the hymnophores of *Boletus*, etc., and *Xerocomus*, and we would designate them as "tubulate" and "faveolate," respectively.

Whether or not there is any organic or morphogenic relationship between the phylloporoid trama and faveolate hymenophore of *Xerocomus* on the one hand and of the bilateral-divergent or boletoid trama and tubulate hymenophore of *Boletus*, etc., on the other, we have no idea. There is, however, an aspect of the situation which has practical application. In specimens, young or mature and not over-mature, and freshly collected or shortly after collection, the two types of hymenophore, and therefore incidentally the two types of trama, can be distinguished by the simple procedure of carefully tearing the pileus from above vertically down through the hymenophore or "tube-layer." The boletoid hymenophore of *Boletus*, etc., will show the intact and untorn tubelets separated in the zone of the mediostratum, and with a knife-point or a pair of forceps one can peel off the individual tubelets intact as such. The phylloporoid hymenophore of *Xerocomus*, on the other hand, will tear down in an irregular manner, without showing any distinct or intact tubelets but with the so-called "tubes" for the most part at least torn across to expose the hymenial layer inside. The results of tearing are the same as would result from separating vertically the mass of cooked macaroni referred to above, and breaking down a honeycomb, respectively. This important difference is illustrated in FIG. 1, above and below.

For several years, we have made this test upon the specimens of the Boletoideae and of *Xerocomus* which we have collected, and we have found that the test was reliable within the limits noted, with a single exception. In all but one of the species of *Xerocomus*, the test has been unfailing whatever the condition—state of maturity, age, or condition of desiccation. The exception has been *X. badius* (Fr.) Kühn. ex Gilbert, which has always torn down in a boletoid fashion rather than the phylloporoid. Singer (**6**, p. 299) states that this trama has an intermediate structure. This species is an anomalous one anyway. It has characters that have led some workers to place it in the genus *Suillus*, but Singer (**6**), agreeing with others that it is best placed in *Xerocomus*, has probably treated it most satisfactorily in a separate section of this genus.

In the Boletoideae, on the other hand, the species vary with regard

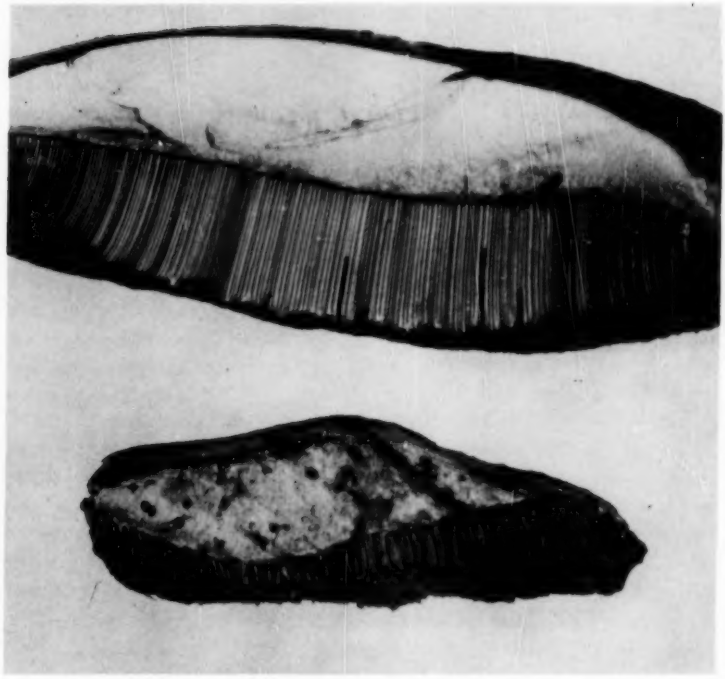

FIG. 1. Sections of fresh, mature carpophores made by carefully tearing from the top of the pileus down through the hymenophore. Above, *Boletus Frostii* Russell *apud* Frost subsp. *typicus* Singer; below, *Xerocomus castanellus* (Pk.) Snell & Dick. $\times 1\frac{1}{2}$.

to the tearing test. Some species will tear down in the proper manner in any stage or condition up to decay or disintegration. In other species, one must exercise due precaution. *Boletus rubellus* Krombh. subspecies *bicolor* (Pk.) Sing. is one of the best examples. This bolete will respond in the expected manner under reasonable conditions of development and natural existence. Specimens not too old or over-mature also will do so after 24 hours or so if protected from desiccation in a refrigerator. On the other hand, the hymenophore of carpophores that are old, over-mature, or deteriorated by insects or other agencies, or desiccated either *in situ* or after collection, will not tear down as expected but in the phylloporoid manner of *Xerocomus*.

BOLETUS EASTWOODIAE

A collection of three *Boletus* specimens made by Georgia Holtz on December 27, 1955, and sent by Esther Whited (both members of the California Mycological Society), was received by us about 48 hours after collection. These specimens were firm and hard, apparently in the early prime of their development, sufficiently mature to cast spores in abundance upon their arrival with us, and certainly in no sense in stages of late maturity or over-maturity. The emphasis on these points will be appreciated when we discuss the colors.

The immediate reaction to these specimens was to call them *B. Eastwoodiae* Murr., except for a few differences, certain of them striking. The description of this species available to us has the surface dry or perhaps moist at times but hardly viscid, even to innately reticulate-areolate, glabrous and shining. These California specimens were definitely viscid, with leaves adhering to the surface, but not viscous, somewhat uneven and mostly glabrous and shining, with a few spots fibrillose-diffract. The chief difference was in colors of the pileus. Our available description gives the surface as sordid white to pinkish-buff to pale olivaceous, more or less pinkish or possibly greenish in places. The surface of the new specimens was purplish-red (Acajou Red, Vandyke Red, perhaps almost Bordeaux of Ridgway), with spots Hydrangea Red, Dark Vinaceous, or tan to dingy tan, and in places more or less speckled dingy olivaceous.

Other characters for the most part did not differ from those in our previous description but seem to be worth recording in detail.

The flesh was Colonial Buff, Massicot Yellow or Straw Yellow, changing to Cendre Blue, Chessylite Blue, Capri Blue, Gendarme Blue, or Patent Blue.

The hymenophore was Olive Ocher to Ecru Olive, turning Lime Green to Mignonette Green and then a dark greenish-blue. The pores were a redder Morocco Red or between Ox Blood Red and Garnet Brown.

The neck of the stipe was from Light Orange Yellow to Deep Chrome to Capucine Yellow. The bulb of the stipe was tinged Alizarine Pink to a paler Spinel Red or Hellebore Red, with areas Ecru Olive to Buffy Olive, Isabella Color or a dingy tan. The entire surface of the stipe changed to blue where bruised. Whereas the reticulation has previously been given as concolorous, these specimens had the reticulation on the neck red to dark red. The flesh of the stipe changed to blue as in the pileus but more greenish toward the outside.

The spores in deposit were between Olive and Brownish Olive. The tube layer stained paper a pale gray-blue and greenish-yellow. The mycelium was pale yellow.

Boletus Eastwoodiae has been recorded as under oaks. These specimens were in a mixture of *Lithocarpus densiflora, Quercus agrifolia*?, *Arbutus Menziesii* and *Sequoia sempervirens.*

In spite of the striking difference in colors of the pileus, we still consider that this collection is *Boletus Eastwoodiae,* that the bright red colors are probably those of early maturity, and that the paler colors of earlier collections represent a faded or weathered condition of later maturity.

LECCINUM AURANTIACUM

Another lot of three fresh specimens, of *L. aurantiacum* (Bull. ex) S. F. Gray, was received from Miss Whited, collected at Boulder Creek, Santa Cruz, California, on January 14, 1956. These were found under *Arbutus Menziesii* in a mixture of madroño and *Lithocarpus densiflora,* and whereas it would seem as though the tan-bark oak were the tree-associate rather than the madroño, on the other hand this bolete is known to have a strange list of associations. Miss Whited reported that specimens of this species had not been common, had been somewhat hard to find, but that she and her friends had been obtaining a few specimens for eating or drying in the preceding weeks.

These carpophores, which had been in the mail for two days, arrived in excellent condition, with the surface of the pilei a bright, fresh orange, the stipes clear white, with whitish to slightly darkened scabrosity, and the flesh firm. The pilei measured 7, 9 and 11 cm broad, and the stipes in length and thickness 13 × 3–5.5 cm, 15 × 3–4.5 cm, and 18 × 3–4 cm, with the two measurements for thickness representing, the first that of the apex and the second that of the thickest portion below. The spores measured 10–21 × 3.5–5.8 μ, with only a very few as small as 10 × 3.5 μ or over 17.5 μ, and the majority 14–16 × 4.5–5 μ.

When the carpophores were cut in halves, the flesh at the base of the stipe was light yellowish with a little pale greenish, and there were bright blue spots just under the cortical region in the lower third of the length, with streaks and tinges of blue toward the base. There were no color changes in either the stipe or the pileus after continued exposure to the air.

An unusual change occurred in the oven-drying of these specimens. The stipes of two of them turned a bright green—Meadow Green of Ridgway, with the darker areas Antique Green—half to most of the

length on the outside, and on the inside in the basal portion and up the cortical region.

BOLETUS EDULIS SUBSP. PINICOLA?

Singer says (**7**, p. 27) that he believes that *Boletus edulis* Bull. ex Fr. subsp. *pinicola* Vitt. has never been found in America.

Among the specimens of boleti received from western United States over the years are several from California, Montana, Wyoming and Colorado, with the forests or nearby trees reported variously as conifers, spruce, or lodgepole-pine and spruce association. These specimens range in size from 8 cm broad to one 28 cm broad with a stipe 15 cm long and 10 cm thick at the thickest part and the tubes up to 7 cm long. These specimens all fit quite exactly the European descriptions of *Boletus edulis* subsp. *pinicola*, except for the size of the spores. Whereas the descriptions give the spores as 14–17 × 4.5–5.5 μ, 13–17.5 × 4.5–6 μ, etc., we find the spores of the specimens in our hands on the whole slightly larger—14–21 × 5–6 μ, with a few 7 μ, mostly 16–18 × 5.5–6 μ, with a tendency for the majority to vary in length directly with the size of the specimens.

In view of the foregoing, we are calling our American specimens *Boletus edulis* subsp. *pinicola* until more information is available, or more careful studies of fresh material can be made.

A NEW SUBSPECIES FROM FLORIDA

At the 1954 foray of the Mycological Society of America at Gainesville, Florida, the junior author obtained some specimens growing in sphagnum (associated trees not recorded), which in size, stature and color remind one of *Gyroporus purpurinus* (Snell) Sing., but along with a different surface and hymenophore, have spores under the microscope somewhat colored and very small, indeed the smallest spores thus far known among the boleti, in mass between Isabella Color and Light Brownish Olive.

This has been a troublesome collection to classify. The size of the spores and the color of the spore print suggested the genus *Phaeogyroporus* described by Singer in 1944 (**5**, p. 360), with species one each from tropical West Africa and South America. It was at first thought that we had found the species which justified Singer's inclusion of the genus in his Florida Boletineae on the basis of "the possibility that at least one of its species may yet be discovered in the state, . . . (**6**, p. 240). On the other hand, we have been unable to find clamps on the hyphae in any part of the carpophores and clamped mycelium is a fundamental character of the subfamily Gyrodontoideae. The only

place these specimens appear to belong is as a small-spored subspecies of *Boletus rubellus* Krombh., nearest to the tropical subspecies *dumetorum* Sing. but differing in several characters as well as the habitat.

Boletus rubellus Krombh. subsp. **purpureus** subsp. nov.

Pileo convexo, humido paulum viscido, glabro, "Madder Brown," "Vandyke Red," "Hay's Maroon," 3–7 cm lato. Carne e pallide lutea alba paulu'um cyanescenti. Hymenophoro adnexo-depresso, luteo, poris concoloribus, brunnescentibus. Stipite subaequali, glabro vel subglabro atque concolori, apice basique minute furfuraceo atque luteo; 5–6 cm × 5–10 mm. Sporis in cumulo inter "Isabella Color" atque "Light Brownish Olive," oblongo-ellipticis, 5–7 × 2.5–3 μ.

Pileus convex when young, becoming plano-convex, 3–7 cm broad. *Surface* somewhat viscid when wet, glabrous, purplish-red (Madder Brown, Vandyke Red or Hay's Maroon of Ridgway). *Flesh* soft, white to pale yellow, changing to very slightly bluish; odor and taste not significant. *Hymenophore* adnexed-depressed, yellow, the tubes 5–7 mm long, the pores concolorous but turning brown with age, medium-sized. *Stipe* subequal, minutely furfuraceous especially at the apex and more or less at the base, glabrous or subglabrous in between, concolorous with the pileus in the middle and yellow above and below, the mycelium yellow; within concolorous with the flesh of the pileus, solid below, hollow above (possibly only as the result of the action of grubs); 5–6 cm long, 5–10 mm thick. *Spores* between Isabella Color and Light Brownish Olive in deposit, oblong-elliptical, pale olive-greenish, 5–7 × 2.5–3 μ, mostly 5.5–6 μ long.

In sphagnum, tree associates not known. Gainesville, Florida.

TYPE specimen, WHS Bolete Herbarium, no. 2145.

BROWN UNIVERSITY
PROVIDENCE, R. I.

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A NEW MARINE PHYCOMYCETE[1]

HELEN S. VISHNIAC

(WITH 8 FIGURES)

In the spring of 1956 egg cases of the oyster drill (*Urosalpinx cinerea*) containing fungal hyphae were collected at the Milford Station of the United States Fish and Wildlife Service. This fungus was subsequently found to be able to infect both ova and early developing stages of *Urosalpinx cinerea* at the Milford Laboratory (**4**) and eggs of *Pinnotheres* at the Marine Laboratory, Plymouth, England (D. Atkins, personal communication). Our laboratory undertook the isolation of this fungus in pure culture, description of its morphology and taxonomic position, and characterization of its nutritional requirements in culture.

METHODS

The fungus was readily isolated by placing hyphal fragments from dissected egg cases on the antibiotic-nutrient-sea-water agar previously described (**9**). Subsequent serial transfers in various stock media currently in use in our laboratory established the suitability of the glucose-glutamate-thiamine semisolid medium used for *Sirolpidium zoophthorum* (**8**). Stock cultures are now routinely maintained by fortnightly transfer in this medium, distributed 5 ml per 20 × 125 mm screw-capped Pyrex or "Kimble" tube. Stock cultures are incubated at 15°, for reasons of convenience. The fungus grows well at temperatures from 15° to 30°, but not at 35°. Stock cultures remain viable for at least three months at 15°.

The conditions under which morphological observations were made are indicated at appropriate places. Nutritional experiments were conducted using the stock medium (with minor variations), with the omis-

[1] It is a pleasure to thank the members of the Milford Laboratory of the U. S. Fish and Wildlife Service for introducing me to this fungus, Dr. D. Atkins for her kindness in examining it, and Miss E. Adair for excellent technical assistance. This research was begun with the support of a contract between the Office of Naval Research, Department of the Navy, and Yale University, NR 135–241, and completed with the support of a research grant, E1179, from the National Institute of Allergy and Infectious Diseases, National Institutes of Health, Public Health Service.

sion of the constituent being studied, as a basal medium. Experimental media were distributed 10 ml per 25 ml Pyrex glass-capped Erlenmeyer flask. After autoclaving and inoculation with 2 or 3 drops of stock culture these flasks were sealed between two Pyrex kitchen trays with Scotch tape and incubated at 25°. Growth was generally completed in 7 days under these conditions. The amount of growth was estimated by visual inspection at intervals during the incubation period. Occasionally the dry weight of mycelium produced was obtained by washing the mycelium on a cheesecloth filter to remove agar (which otherwise greatly hampers later filtration), washing the mycelium off the cheesecloth onto a weighed, dry circle of filter paper in a Gooch crucible with minimal amounts of distilled water, and drying to constant weight in a vacuum desiccator over silica gel. It is probable that fragments of mycelium are lost during these operations. The weights obtained are offered as approximations useful perhaps for comparing the efficiency of this species with that of other fungi in converting substrate to mycelium. A weight of 3.0 mg of dry mycelium is obtainable from growth on 5 mg each of glucose and NaH·glutamate; 3.7 to 7.1 mg of dry mycelium from growth on 20 mg of glucose and 5 mg of NaH·glutamate under the conditions used.

MORPHOLOGY

Vegetative mycelium: In stock cultures on semisolid (0.1% agar) medium this fungus grows at temperatures from 15° to 30° as an extensive, branched, filamentous mycelium of somewhat irregular diameter, usually 10 to 13 μ, frequently increasing with age to as much as 25 μ, with occasional bulbous swellings up to 40 μ (rarely more) in diameter. The appearance of the protoplasm varies with physiological age, at first clear or slightly granular and foamy (FIG. 1), later often with large round vacuoles (FIG. 2) resembling those described by Sparrow (**6**, pl. 2, f. f) in *Sirolpidium Bryopsidis*, by Vishniac (**8**) in *Sirolpidium zoophthorum*, and by Apstein (**2**) in *Synchactophagus balticus*. In old age these vacuoles become so enlarged as to leave a highly granular protoplasm occupying the position of the rungs on a ladder (see FIG. 5). When grown on media (isolation medium or stock medium) solidified with 1.5% agar the hyphae become stouter, increasing irregularly in diameter to 56 μ and producing lobed or oval to almost spherical swellings. Desiccation or mechanical injury results in the formation of new thalli within the old cell wall by protoplasmic fragmentation as in the Sirolpidiaceae (see **8**). If the mycelium is cut or broken, spherical masses of protoplasm, 15 to 40 μ in diameter, may escape, produce new

cell walls, and continue to grow vegetatively. Occasional shaking of stock cultures grown at 15° produced cultures rich in such fragments and therefore useful as a readily pipettable inoculum for various sorts of experiments. At 25° more rapid growth quickly produced a dense surface mat of mycelium which was difficult to break up. Crosswalls, other than the new walls produced after obvious retraction of masses of protoplasm within the original filament, were never formed, nor were rhizoids observed under any conditions of culture or in the egg cases.

Gemmae: Under suboptimal conditions of growth the entire mycelium developed the scalariform appearance previously described and eventually lysed. Under more favorable circumstances the protoplasm, between the fifth and seventh days of culture at 25°, somewhat later at lower temperatures, retracted lengthwise within the filaments into irregular sections, forming gemmae with the usual dense non-vacuolate protoplasm and thickened cell walls (FIG. 3). These structures appear to be responsible for the viability of the stock cultures after the period of active vegetative growth is past.

Sexual reproduction: Where the mycelium has become considerably swollen and bulbous, the retraction of the protoplasm during the production of gemmae may lead to the formation of a sphere or near sphere. The result has something of the appearance of an oosphere or oospore (FIG. 4). I am inclined to think that neither these nor similar structures in other filamentous holocarpic Saprolegniales are oospores. If an oospore is defined narrowly as a thick-walled spore resulting from fertilization of a female gamete indeed such structures cannot be oospores, since no antheridia nor male thalli have been observed in any filamentous holocarpic member of the Saprolegniales. It is more usual to apply the term oospore also to parthenogenetic resting bodies of similar morphology. The differences between parthenocarpic oospores and other asexual non-motile reproductive bodies—gemmae or chlamydospores—in related fungi are these: (1) One or more oospores are produced within an oogonium which is either an entire thallus (in holocarpic species) or a portion of the thallus cut off by a true septum from the remaining mycelium (in eucarpic species). A gemma is produced by the direct metamorphosis of a vegetative cell, not within a container. The gemmae of the present fungus are typically derived from thalli resulting from protoplasmic fragmentation within the old wall of the original thallus, but the process of fragmentation appears to be distinct from, and need not lead to, the formation of gemmae. (2) The oospore is a more or less spherical body of a characteristic (to each species) size range which is not correlated with oogonium size (except perhaps in

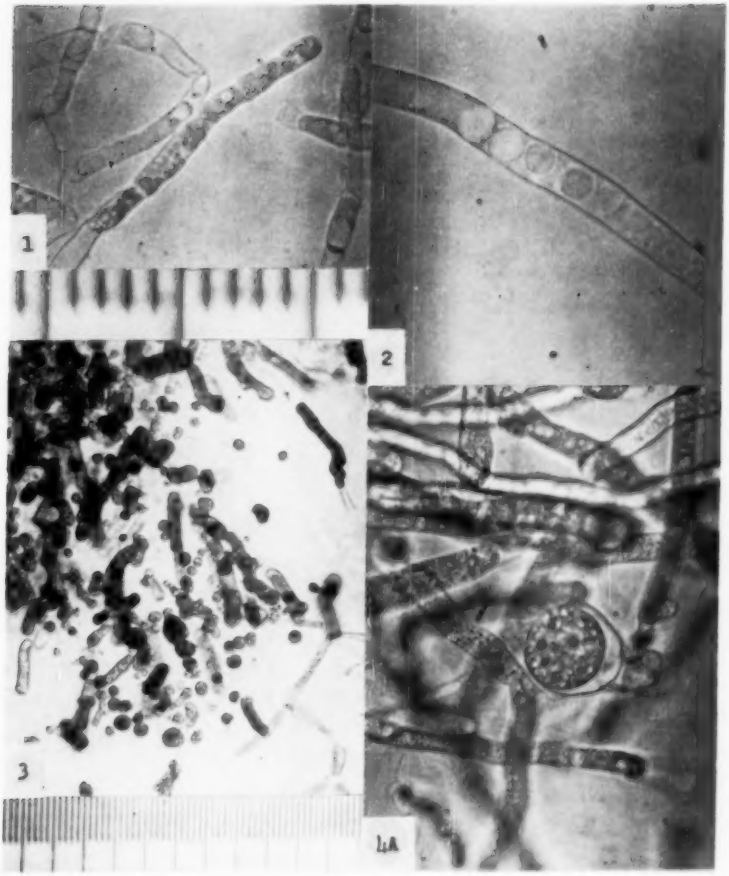

FIG. 1. Growing tip from two-day-old stock culture. Hyphae damaged in preparation. (Scale for FIGS. 1, 2, 4, and 6 below. 1 division equals 10 μ.) FIG. 2. Vacuolate hypha from seven-day-old stock culture. FIG. 3. Mycelium bearing gemmae; from nineteen-day-old culture (15°) on stock agar. (Scale for FIGS. 3 and 5 below. 1 division equals 10 μ.) FIG. 4A. Young spherical gemma from ten-day-old (15°) sporulation preparation.

the extreme case of typically monosporous species in which oogonial dimensions vary much less than usual). The disposition of food reserves may also be distinctive and characteristic, as in the Saprolegnia-

ceae. Gemmae range from structures indistinguishable in shape from vegetative cells or hyphae to those rounded bodies which are more generally called chlamydospores. The dimensions of gemmae may consequently be highly variable. There is no characteristic arrangement of food reserves. The oospore-like bodies of the present fungus resemble its gemmae in every respect except shape—in which they may represent an extreme made possible by the bulbous swelling of the original thallus at the point of their formation. They vary in diameter from 15 to 50μ, tending to approximate the diameter of the original thallus. For these reasons, and because neither the whole thallus nor a segment separated by a true septum is devoted to the production of these bodies, they should be considered gemmae rather than oospores. Sexual reproduction has not been observed in this fungus.

Sporulation: Sporulation has never occurred during culture, nor when petri plates of nutrient, dilute nutrient, or plain sea-water agar inoculated with this fungus are flooded with sterile sea water. Sporulation was frequently, but not invariably, induced by placing 1 ml of stock culture in a petri plate with 10 ml of sterile sea water, and washing with sea water every second or third day. If zoospore formation and discharge occurred at all, cystospores, motile zoospores, and spore formation and discharge were visible on the seventh day, but not on the fifth. Continuous incubation at 15°, 20°, or 25°, or varying the temperature from 15° to 25°, or using room temperature, made no difference in the time or regularity of zoospore formation. The age of the stock culture used (never less than 2 days) seems also to be immaterial. When these preparations were set up and washed with varying concentrations of sea water (100, 80, 60, 40, 20, and 10% in distilled water), sporulation occurred only with 100 to 60% sea water. Light (continuous, only at examination, or naturally alternating) had no apparent effect on sporulation.

The sequence of events in the transformation of a thallus into a sporangium has not been continuously observed. At the time of zoospore discharge it can be seen that the entire contents of the thallus have been cleaved into a close-packed mass of zoospores. Since all the protoplasm of a thallus is involved in reproduction, this fungus must be regarded as holocarpic. Holocarpy in such a filamentous fungus may be confused with that variety of eucarpy in which a number of undifferentiated sporangia are produced. The sporangia of a eucarpic fungus are, however, always separated from the remainder of the thallus by cross-walls, even if non-reproductive protoplasm in the form of rhizoids is

not present. Cross-walls are never formed in the present fungus. The difference between the formation of new wall material around a subthallus (most clearly seen in FIG. 4B) and the formation of a true cross-wall is best appreciated by comparison of these processes in fungi which do both. In *Sirolpidium zoophthorum*, as in the present fungus, protoplasmic fragmentation is completed by the apparent formation of an entire new cell wall around the fragment, visibly free from the old thallus wall for much of its extent (**8**, Figs. 5, 6), while the true septum (**8**, Fig. 7) cuts through the protoplasm (instead of surrounding an already separated fragment), making an integral connection with the original filament wall.

The zoospores squeeze in an amoeboid fashion through the single exit tube, emerging as free-swimming, laterally biflagellate, "kidney-shaped" swarmers which in size (roughly 8 or 9 μ diameter), shape, and motion resemble the familiar zoospores of *Pythium* or of the second stage of swarming in the Saprolegniaceae. As the thallus empties, the remaining zoospores become motile by means of the flagella before entering the narrow exit tube. A large birefringent granule, sometimes accompanied by smaller granules, was usually seen at the posterior end of the swimming zoospore. Such granules or "oil globules" are more characteristic of uniflagellate than of biflagellate zoospores but have been found frequently in the Ectrogellaceae among the Biflagellatae (see Sparrow, **7**).

The exit tubes (illustrated in FIG. 5) are irregularly wavy to partly coiled structures, usually originating at one end of the thallus. They have also been observed in other positions—for example, 100 μ from the end of a sporulating thallus 350 μ long. The diameter of the exit tube is usually 6 or 7 μ (ranging from 4.5 to 9 μ, but with little variation in the diameter of individual tubes); their length ranges from 100 to 725 μ, usually around 400 μ.

After a swarming period which may exceed 48 hours, the zoospores encyst. The cystospores are usually about 8 μ in diameter, with the persistent birefringent granule of up to 2 μ diameter generally visible near the cell wall. In sea water the cystospores germinated with the production of a hair-like filament less than 0.5 μ diameter, frequently branched once, and up to at least 72 μ long (FIG. 6). When such germinated cystospores were transferred to plates of stock agar the tip of the hair-like filament proceeded to enlarge and grow as a hypha of the usual size, as it did a short distance after penetrating an egg of *Pinnotheres* (D. Atkins, personal communication). The cystospore

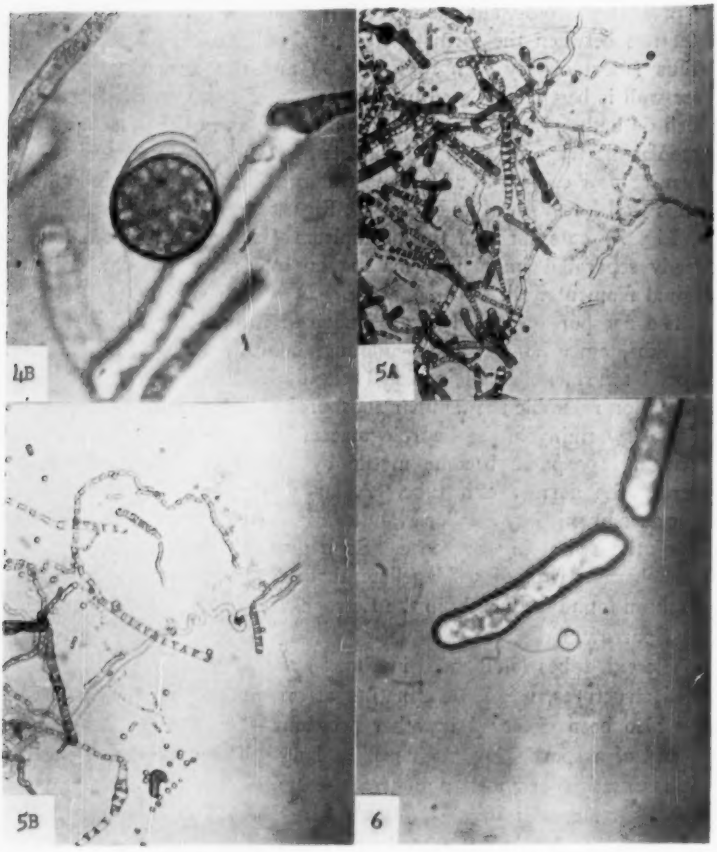

FIG. 4B. Young spherical gemma from ten-day-old (15°) preparation. FIG. 5A, B. Seven-day-old sporulation preparation showing exit tubes. FIG. 6. Germinating cystospore; same preparation as FIG. 5. Note birefringent granule in cyst.

and filament remained visible for at least two days after transfer to agar. When ungerminated cystospores are transferred to stock agar they increase isodiametrically to about 10 μ diameter and then grow out as normal hyphae, usually producing the first branch about 100 μ from the cystospore end of a 200 μ long thallus. The hair-like filaments are then a morphological adaptation for infecting the host, formed only when readily assimilable substrates are not present.

TAXONOMY

The foregoing description clearly places our fungus among the Phycomycetes, Biflagellatae, Saprolegniales. There is at present no family among the Saprolegniales to which a holocarpic form with such extensive mycelial development can be unhesitatingly assigned. The Ectrogellaceae of Scherffel (**5**, p. 6) was proposed to include all holocarpic Saprolegniales. This family (vide **7**) consists of (a) genera with nonfilamentous thalli and, typically, minute (at most $3 \times 5\,\mu$) zoospores—*Ectrogella, Eurychasma, Eurychasmidium;* and (b) *Aphanomycopsis* Scherffel (**5**, p. 11) in which the thallus is branched and filamentous to the extent allowed by its endobiotic development in freshwater diatoms, and the zoospores large ($10–12 \times 7–8\,\mu$). *Aphanomycopsis bacillariacearum* (the type of this genus, **5**, p. 14) differs from the present fungus in that the zoospores encyst at the mouth of the exit tube, as well as in greater delicacy ($6–10\,\mu$ hyphal diameter) and fresh-water habitat. Structures which have been interpreted as possible oospores are produced (**5**, pl. 1, f. *32*; see *Sexual reproduction* above).

The two other filamentous holocarpic Saprolegniales which have been described are marine fungi which like the present form apparently lack sexual reproduction: *Plectospira dubia* Atkins (**3**) and *Synchaetophagus balticus* Apstein (**2**). Both have been placed in the Saprolegniaceae (though the position of *Synchaetophagus* in this family has sometimes been considered questionable)—a choice of affinities which seems dubious in view of the established eucarpic character of the more typical members of that family. The development of *Plectospira dubia* on crustacean eggs and crustacea has been described in detail by Atkins (**3**). It clearly differs from the present fungus in that the zoospores of *P. dubia* are diplanetic, usually encysting within the sporangium and emerging in the second swimming stage. Dr. Atkins has kindly infected *Pinnotheres* eggs (one of the hosts of *P. dubia*) with the present fungus and finds (personal communication) that the two fungi differ also in the characteristic appearance of the protoplasm in ways which are difficult of verbal description and so perhaps less useful in definition than the behavior of the zoospores, though in my opinion equally real. Zoospores and cystospores of *P. dubia* are essentially the same size as those of the present fungus.

Synchaetophagus balticus was described by Apstein (**2**) as epidemic on the rotifer, *Synchaeta,* in the Baltic Sea. It has since languished in both physical and literary obscurity (Ainsworth and Bisby, **1**, list it as "? Phycomycetes")—the latter no doubt because Apstein, under the

influence of the then prevailing ideas as to the importance of sexual reproduction in the systematics of the Phycomycetes, refused to place his new genus in any larger category. From a more current point of view, Apstein's failure to describe the flagellation of the zoospores, or to observe whether they were mono- or diplanetic, is much more serious. This omission makes *Synchaetophagus balticus*, in my opinion, a *nomen dubium*. The features described by Apstein are, however, sufficient to indicate that there exists at least one branched filamentous holocarpic phycomycete in which zoospores are produced in the thallus (rather than in a vesicle), differing from *P. dubia* and the present fungus in hyphal diameter (5 to 8 μ) and the production of zoospores in a single row, from *Aphanomycopsis* and *P. dubia* in that the zoospores do not encyst either at the mouth of the exit tube or within the thallus.

There are then three (or four, if Apstein's fungus is heterokont) fungi which differ from the majority of the similarly holocarpic Ectrogellaceae in the production of a more or less extensive, branched thallus as well as in the typical size of the zoospores or cystospores. All of these fungi are excluded from the Thraustochytriaceae and the Saprolegniaceae by their holocarpy. They share with the Saprolegniaceae extensive mycelial development and the characteristic zoospore size. The Thraustochytriaceae are differentiated from the Saprolegniaceae by their archimycetous thallus and small zoospores—as are the Ectrogellaceae from the group under consideration. The use of holocarpy as a familial distinction has even greater historical precedent. The use of the entire protoplasm at one time for reproduction severely limits the possibilities for the dissemination of the species and for the evolutionary development of morphological complexity. This character is therefore of fundamental theoretical importance. From this point of view it is not surprising that the filamentous holocarpic forms should be few compared to the numerous species of the eucarpic Saprolegniaceae. The erection of a new family is therefore justified by the existence of a group of fungi possessing common characteristics which have previously been found useful in making familial distinctions. This family would include the present fungus, *Plectospira dubia* Atkins, *Aphanomycopsis* Scherffel, and possibly Apstein's fungus.

All of the families of the Saprolegniales demonstrate parallel evolution of the gradual suppression of diplanetism. The degree of suppression constitutes the major generic distinction among the Saprolegniaceae and will be so used in differentiating the genera of our proposed new family.

The following new taxa are therefore proposed:

Haliphthoraceae fam. nov.

Saprolegniales diatomarum aut animalium invertebratorum marinorum parasiti, myceliis ramosorum filamentorum sed septis non praeditis et omnino in sporas dividentibus. Zoosporae sic in thallo formatae magnae, monoplaneticae aut diplaneticae. Si modo sexuali generant ignotum est.

Filamentous, branching, holocarpic Saprolegniales parasitizing diatoms or marine invertebrates. Large mono- or diplanetic zoospores produced within the thallus. Sexual reproduction unknown.

Haliphthoros gen. nov. (the destroyer on the sea, or pirate)

Haliphthoraceae quae zoosporas monoplaneticas, flagellis lateralibus binis, producunt.

Zoospores monoplanetic, laterally biflagellate. Otherwise characters of the family. Monotypic, and the type genus of the Haliphthoraceae.

Haliphthoros milfordensis sp. nov.

Thallus ramosis filamentis, iuvenis 10–13 μ diam., deinde usque ad 56 μ diam. irregulariter crescens, et vacuolis magnis praeditus. Septa non formata sed thallus saepe intra muros in thallulos novos fractus. Thallus omnino in sporas dividens. Zoosporae ca. 8–9 μ diam., monoplaneticae, flagellis lateralibus binis, emergentes per tubulum solum (4.5–)6–7(–9) $\mu \times$ (100–)400(–725) μ. Sporae in capsulis tubuli tenuis modo germinantes, aut, si alimentum habent, filamentum consuetum producentes. Gemmae quoque formatae.

Parasitus in ovis *Urosalpingis cinereae*, Milford, Conn.

The description and illustrations here presented constitute the type of this species.

Atkinsiella gen. nov.

Haliphthoraceae quae zoosporas diplaneticas, capsulas primas plerumque intra thallum formantes, producunt.

Zoospores diplanetic, usually encysting within the thallus and emerging in the second swimming stage. Otherwise characters of the family. TYPE: **Atkinsiella dubia** (Atkins) comb nov.

Syn.: *Plectospira dubia* Atkins, Jour. Mar. Biol. Ass. U. K. **33**: 731. 1954.

NUTRITIONAL REQUIREMENTS

The consistent growth of *Haliphthoros milfordensis* on the stock medium used indicated that its organic nutritional requirements were no more complex than those of the majority of cultivable fungi. Our

TABLE I

GROWTH OF HALIPHTHOROS MILFORDENSIS IN VARIOUS CONCENTRATIONS OF NaCl

NaCl	0	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%	5.0%
Growth	0	±	+⁺	++	++⁺	+++	+++	++⁺	++	+⁺

0 indicates no growth; ± to +++ increasing amounts of growth from traces to excellent.

experimental efforts were therefore confined to determining (a) the necessity for certain of the major inorganic components of sea water and (b) the effects of a few simple qualitative and quantitative variations in the organic compounds included in the stock medium.

Salt requirements: *Haliphthoros milfordensis* can only complete its life cycle (*i.e.* form gemmae or zoospores) in sea water or a synthetic approximation of sea water, and will not grow if NaCl is omitted from the medium. This fungus is therefore obligately marine although it will grow vegetatively in the presence of inorganic salt solutions which differ very greatly from normal sea water: it is euryhaline. The effect on growth of varying concentrations of NaCl is shown in TABLE 1. Growth at 0.5% and 1.0% NaCl was grossly abnormal, with a clumped, feathery appearance which on microscopic examination appeared to be the result of contortion and irregular inflation of the hyphae to approximately 25 μ in diameter. Growth was completed with maximal formation of gemmae at 2.0, 2.5, and 3.0% NaCl in this experiment. In a subsequent experiment gemmae were produced at 2.0% NaCl but not at 3.0% NaCl. $MgSO_4 \cdot 7H_2O$ could be omitted or increased to 0.7% without greatly affecting growth under our conditions, though some inhibition was noted at both extremes of concentration. The results of varying KCl (in the presence of NaCl, 2.0%, in this experiment) are shown in TABLE 2. Gemmae were produced in the presence of 5 to 100 mg per 100 ml of KCl, most abundantly at 50 mg per 100 ml KCl.

TABLE II

GROWTH OF HALIPHTHOROS MILFORDENSIS IN VARIOUS CONCENTRATIONS OF KCl

KCl	0	5	10	20	50	100	200 mg per 100 ml
Growth	+	+⁺	+⁺	+⁺	++	++	++

+ to ++ indicate increasing amounts of growth from poor to good.

TABLE III

GROWTH OF HALIPHTHOROS MILFORDENSIS IN VARIOUS CONCENTRATIONS OF GLUCOSE AND NaH·GLUTAMATE

Glutamate	Glucose 0.05%	0.2%
0	±?	±
0.005%	+	+*
0.01%	+*	++?
0.02%	++?*	++
0.05%	++**	++
0.1%	++**	+++
0.2%	++*	+++

±? to +++ indicate increasing amounts of growth from traces to excellent. * and ** indicate increasing formation of gemmae. Mycelia from the second column were too young after the seven-day incubation period to have formed gemmae; the pH of only the last flask in this column was favorable for gemma formation at harvest. The basal medium for this experiment included Na_2EDTA instead of EDTA and contained only 0.1 mg per 100 ml each of Zn^{++} and Mn^{++}.

Growth when KCl was omitted was contorted, with the formation of many short terminal branches.

Organic requirements: *Haliphthoros milfordensis* grows poorly with glucose supplied as sole carbon source at concentrations from 0.05 to 0.2%, and only slightly better with NaH·glutamate, 0.025 to 0.1%, as sole substrate. Best growth is made, and gemmae are formed, when approximately equimolar concentrations of glucose and NaH·glutamate are available (TABLE 3). Growth in the presence of excess glucose

TABLE IV

GROWTH OF HALIPHTHOROS MILFORDENSIS ON VARIOUS SOURCES OF CARBON AT 0.05% (IN THE PRESENCE OF NaH·GLUTAMATE)

Carbon source	Alone	With glucose
None	+	+++
Glucose	+++	+++
Fructose	+	+++
Sucrose	+	+++
Ribose	+	+++
Soluble starch	++*	+++
Ethanol	+	+++?
Glycerol	+++	+++
Mannitol	+	+++
Na·gluconate	+	+++
Na·acetate·$3H_2O$	+	+++?
Na·lactate	+	+++
DL-alanine	++	+++

+ to +++ indicate increasing amounts of growth from poor to excellent. All sugars and ethanol were added aseptically after sterilization of the basal medium, as is customary. Sugars were sterilized by filtration through sintered glass. The basal medium for this experiment included Na_2EDTA (instead of EDTA), $(NH_4)_2SO_4$ (instead of $(NH_4)_2CO_3$), and $NaHCO_3$ (added aseptically after sterilization to a final concentration of 0.02%).

resulted in a drop of the initial pH (7.5 before autoclaving) to as low as 5.8, while an excess of glutamate gave a final pH sometimes reaching 8.0. The final pH in cultures in which gemmae were produced varied in different experiments between 7.0 and 8.0, usually 7.4–7.8. Glucose is replaceable (in the presence of glutamate) only by soluble starch and glycerol among eleven commonly available carbon sources (TABLE 4) though some growth, but no gemmae, occurs with DL-alanine. Glutamate is replaceable by aspartic acid (neutralized with NaOH) on a roughly equimolar basis. Glutamate is not replaced by DL-alanine, citrate, succinate, or acetate at approximately equal concentrations in terms of carbon content, molarity, or physiological buffering capacity.

The thiamine included in the stock medium is not required by *Haliphthoros milfordensis*. A series of nine transfers in a completely liquid medium lacking thiamine resulted in no diminution of growth, nor was growth increased when such thiamine-depleted cultures were transferred to media containing thiamine or containing a mixture of known B-vitamins. This experiment was performed using larger inocula than usual and using the stock medium (without agar) with an increased concentration of Mn (a total of 4.0 mg per 100 ml of Mn as $MnSO_4 \cdot H_2O$) in culture tubes. The cultures were incubated at 15° to assure a more uniform inoculum than was possible under the conditions usually used for nutritional experiments. In a parallel experiment the thiamine-requiring *Sirolpidium zoophthorum* completely failed to grow on the fifth transfer unless returned to media containing thiamine.

SUMMARY

A marine fungus isolated from egg cases of *Urosalpinx cinerea* is described as *Haliphthoros milfordensis*, a new species and new genus which is made the type of a new family, the Haliphthoraceae, of filamentous holocarpic Saprolegniales. The Haliphthoraceae include as well the new genus *Atkinsiella* and *Aphanomycopsis* Scherffel. *Synchaetophagus balticus* is a *nomen dubium*.

Haliphthoros milfordensis is obligately marine but euryhaline. This fungus grows well in a synthetic sea-water medium containing approximately equimolar concentrations of glucose (or soluble starch or glycerol) and NaH·glutamate (or Na·aspartate). Vitamins are not required.

DEPARTMENT OF MICROBIOLOGY
YALE UNIVERSITY
NEW HAVEN 11, CONN.

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PHYSODERMA PULPOSUM

YAMUNA LINGAPPA

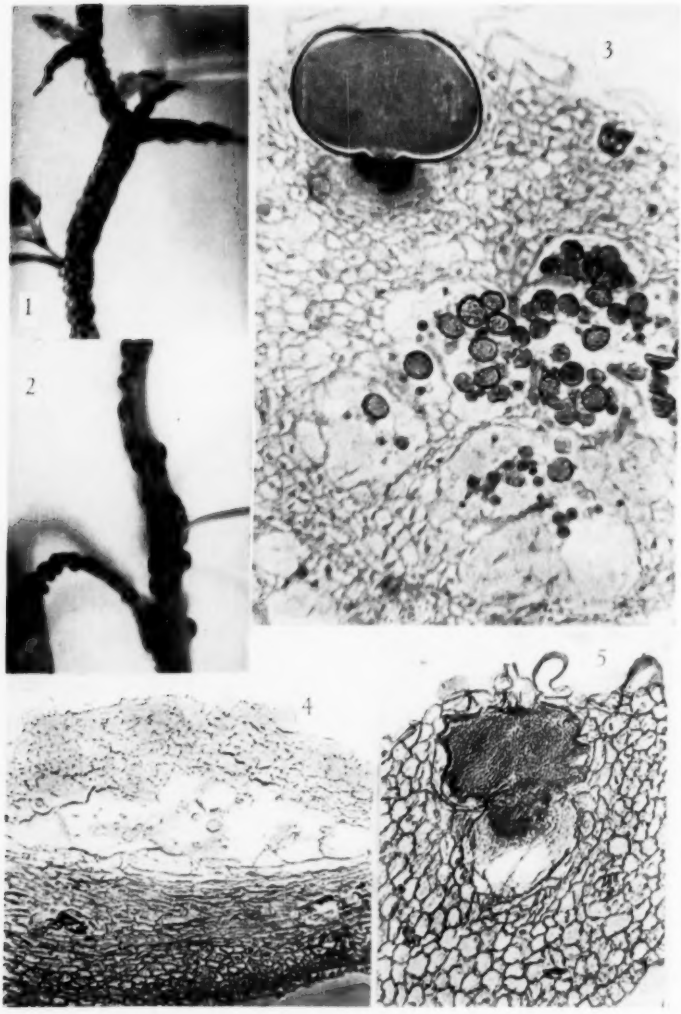
(WITH 5 FIGURES)

Physoderma pulposum (Wallr.) Karling was described by Wallroth (**1833**) on *Atriplex angustifolia,* and *Chenopodium* sp., and later made the type species of the genus *Urophlyctis* by Schroeter (**1882**) on the ground that it develops epibiotic ephemeral zoosporangia and on his belief that the resting sporangia are formed by the fusion of two similar cells. Since that time it has been reported on a large number of hosts, including *Atriplex hastata* (Sweden), *A. litoralis* (Hungary), *A. patula* (Germany), *A. pratensis* (Argentina), *Aegopodium podagraria* (Austria), *Ambrosia bassi* (Sardinia), *Blitum rubrum* (Sweden), *Beta vulgaris* (Palestine), *Chenopodium glaucum* (Yugoslavia), *C. murale, C. album, C. hircinum, C. rubrum* (Argentina), *C. crassifolium* (Hungary) by numerous workers (*cf.* Karling, **1950**). It has also been recorded on *Chenopodium glaucum* and *Atriplex hastata* in South Dakota, U. S. A.

This species was collected during May to October, 1955–1957, on *Atriplex patula* var. *hastata* (L.) Gray in the vicinity of Purdue University at Lafayette, Indiana. Intensive field observations indicated that it did not infect the *Chenopodium album* L. plants in the field, although they were growing together with heavily infected *A. patula* plants. However in 1956, in a remote place, five miles south of Lafayette, Indiana, only *C. album* plants were found parasitized by a fungus which was found to be similar to *P. pulposum.* The morphology and life-cycle of both fungi, and the symptoms produced on the respective hosts, were alike. The two fungi were continuously maintained on their respective hosts for two years in the greenhouse by periodical inoculations. However, when zoospores from the epibiotic, ephemeral sporangia of *A. patula* are placed on *C. album* and vice versa, only abortive galls were produced. Only rarely were small viable epibiotic sporangia produced amidst numerous abortive galls when heavy inoculations were made, whereas under similar conditions the respective host plants were readily infected. This indicated that the two collections represent different *formae speciales,* of *P. pulposum.* Repeated infection experiments using

both forms separately on *Beta vulgaris, Chenopodium ambrosioides, C. bonus-henricus, C. botrys, C. majus, Spinacia oleracea* and *Trifolium subterraneum* plants have so far failed. These results indicate that *P. pulposum* may have a limited host range and that the reports of its occurrence on other hosts besides *Atriplex patula* and *Chenopodium album* may be incorrect. On the other hand, it is quite possible that these reports may relate to forms or biological races of *P. pulposum* which have primary hosts but may infect secondary hosts sporadically like *Synchytrium aureum* Schroet. Obviously, these questions cannot be settled until intensive cross inoculations have been made with the fungi reported on the various hosts.

As noted above, the life cycle of *P. pulposum* includes an epibiotic ephemeral sporangial phase and an endobiotic rhizomycelioid resting sporangial phase with haustoria and turbinate cells. The planospores infect the epidermal cells of the host and develop into the epibiotic sporangia whose basal tufts of rhizoids are intramatrical. The infected epidermal cell enlarges considerably, and, as the rhizoids develop, its walls as well as those of the subepidermal cells in the immediate vicinity lyse partially to form a limited lysigenous cavity (FIGS. 3, 5). At the same time the healthy neighboring epidermal and some subepidermal cells are stimulated to divide by the presence of the parasite so that eventually the sporangia become partly or almost completely enveloped by the derivatives of such cells (FIG. 5). In this manner raised superficial and almost hemispherical galls are formed on the surface of the host which may be up to 1 mm high and 2 mm in diameter. On *A. patula* the galls appear pale yellow, and on *C. album* they may become pinkish. These galls resemble those incited by species of *Synchytrium* so closely that when they were first collected in the field the author believed that they related to a species of this genus instead of to *Physoderma*. The epibiotic sporangia are subspherical, ovoid or almost hemispherical, 60–350 μ in greatest diameter, with a hyaline wall and bright lemon-yellow content. Under the stereoscopic microscope their glistening yellow convex apex is visible in the middle of the galls. After the sporangia have discharged the planospores the galls appear crateriform or cupulate. A single gall may contain 1–5 or more sporangia, and reinfection of the gall cells as well as overcrowding of sporangia from heavy initial infections results in the formation of extensive, confluent and crustaceous galls as shown in FIG. 1. The shoots of the host so infected become thickened and distorted and appear yellow to pink and finally brown. The planospores from the epibiotic sporangia may function as zoospores, reinfect the host and develop into epibiotic sporangia, or function as



FIGS. 1–5.

FIGS. 1–5. *Physoderma pulposum* on *Chenopodium album*. 1. Symptoms incited by over-crowded development of epibiotic sporangia, ½ natural size. 2. Symptoms incited by the endobiotic phase, ½ natural size. Both symptoms were induced by inoculation in the greenhouse. 3. Cross section through a petiole, 10 days after

gametes and fuse. However, the results so far obtained indicate that fusion occurs only between gametes from different sporangia. When plants are inoculated with planospores from a single sporangium only epibiotic sporangia develop. When planospores from two or more sporangia are mixed numerous fusions occur, and the number of fusions appears to be correlated with the "ripeness" of the sporangia from which the gametes are derived. When such a mixture is used as an inoculum both phases develop on the host. These results suggest that the zygotes give rise to the endobiotic phase, while the planospores give rise to the epibiotic phase.

The endobiotic phase first becomes visible in the epidermal cell of the host as a turbinate enlargement from which the rhizomycelium, secondary, tertiary, etc., enlargements, and resting sporangia develop in succession. As the rhizomycelium invades the deeper-lying tissues the host cells enlarge and their walls lyse. This leads eventually to the formation of extensive subepidermal lysigenous cavities, 100–300 × 200–600 μ, in which numerous resting sporangia occur. The healthy host cells surrounding these cavities begin to divide as the rhizomycelium spreads, and as a result hard tumerous galls are formed, as is shown in FIGS. 2 and 4. A large gall may include several lysigenous cavities filled with resting sporangia (FIG. 3). It is thus obvious that both phases of *P. pulposum* stimulate the development of characteristic galls (FIGS. 1, 2). The evanescent epibiotic and endobiotic resting sporangia are initially uninucleate but soon become multinucleate. Mitosis is typically intra-nuclear with a conspicuous spindle, 3 × 5 μ, which stretches across the entire nuclear cavity. The lunate nucleolus lies at one side of the nuclear membrane, and four chromosomes are frequently visible. After a period of dormancy, the resting sporangia germinate by developing a so-called endosporangium. A stellate opening is formed in the thick sporangial wall through which the endosporangium protrudes and releases the planospores. Less than a hundred planospores are formed by the resting sporangia in contrast to the several thousands produced in ephemeral epibiotic sporangia. The planospores from resting sporangia function as zoospores and develop into epibiotic sporangia when they infect the host. So far no fusions have been seen among these planospores and no endobiotic stages have resulted when they were used as an inoculum.

inoculation, showing superficial epibiotic and deep-seated endobiotic phase, × 100. 4. Cross section through gall produced by endobiotic phase, showing extensive lysigenous cavity, × 200. 5. Six-day-old epibiotic sporangium, showing a limited lysigenous cavity around bushy rhizoid, × 200.

In connection with *P. pulposum* the author has studied *P. hemisphericum* (Speg.) Karling on *Carum Carvi* from Colorado (leg. G. B. Cummins, 1956) and a *Physoderma* species on *Trifolium subterraneum* from Australia (leg. N. T. Flentje, 1956). The latter fungus resembles *P. alfalfae* very closely but parasitizes *T. subterraneum* exclusively. According to communications from Dr. Flentje, alfalfa and other legumes were growing together in the same field with the parasitized clover, but they were not infected.

The resting sporangia of both these species germinate in the same manner as those of *P. pulposum* by developing an endosporangium and cracking the exospore to form an irregular opening. The planospores of *Physoderma* sp. on *T. subterraneum* are ovoid or obpyriform, 3.5 × 5.5 μ, with a prominent refractive globule and an 18–20 μ long flagellum. So far no epibiotic phase has been observed in this species.

Thus, *P. pulposum*, *P. hemisphericum*, and *Physoderma* sp. on clover are all inoperculate species in so far as the germination of resting sporangia is concerned. In *P. pulposum* the epibiotic ephemeral sporangia are also inoperculate. This indicates the existence of operculate and inoperculate species in the genus. Furthermore, other prominent characters are under study in *P. pulposum*. The work is being conducted under the direction of Dr. J. S. Karling to whom the author is very grateful for guidance, encouragement, and facilities. The author is highly thankful to Dr. G. B. Cummins and Dr. N. T. Flentje for *Physoderma* materials. She is also thankful to Dr. Cummins and to her husband Dr. Lingappa for taking photographs. The work is supported by a fellowship of the Cancer Research Fund of the Indiana Elks association.

DEPARTMENT OF BIOLOGICAL SCIENCES
PURDUE UNIVERSITY
WEST LAFAYETTE, INDIANA

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PARASITIC AND SAPROPHYTIC PHYCOMYCETES WHICH INVADE PLANKTONIC ORGANISMS. I. NEW TAXA AND RECORDS OF CHYTRIDIACEOUS FUNGI

R. A. Paterson [1]

(with 2 figures)

Investigations of parasitic and saprophytic fungi which invade planktonic organisms are of interest to both the mycologist and limnologist. Indeed, a knowledge of the taxonomy and morphology of these fungi as well as an understanding of their role in the ecology of the lacustrine habitat is of fundamental importance to such workers. The most recent studies concerned with the mycology of planktonic fungi have been made by Jaag and Nipkow (**1951**) in Switzerland, Sparrow (**1951**) and Paterson (**1956**) in the United States, and Canter (**1950, 1951, 1954**) in England. Limnological investigations of these organisms have been made by Canter and Lund (**1948, 1951, 1953**) in the English Lake District and by Paterson (**1957**) in a lake in southern Michigan.

It is the purpose of this paper to present some of the planktonic chytridiaceous parasites and saprophytes encountered during the course of an investigation of these fungi in several Michigan Lakes from 1953 to 1956. In addition to the description of two new species, the status of two incompletely known taxa is further clarified and several new records for the United States are reported.

Rhizophydium pelagicum sp. nov. (Fig. 1, A–G)

Sporangium sessile, late ellipsoidale, membrana levi, 11–17.5 μ longum, 8–11.5 μ crassum; systema rhizoidale crassum, ramosum, graditim minus; zoösporae numerosae sphaericae, 3 μ diametro, globulo refractivo et singulari, 1.5 μ in diametro, flagello postico, 15 vel 16 μ longo praeditae, deliquescentia superioris partis membranae sporangialis emmisae. Sporae perdurantes non observatae.

Sporangium sessile, broadly ellipsoid, smooth-walled, 11–17.5 μ long by 8–11.5 μ in diameter; rhizoids coarse, branched and tapering; zoö-

[1] This paper forms a part of a thesis accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy in the University of Michigan.

spores numerous, spherical, 3 μ in diameter with a single eccentric refractive globule, 1.5 μ in diameter, and a posterior flagellum, 15 to 16 μ long, escaping by the deliquescence of the entire upper half of the sporangial wall; resting spore not observed.

Parasitic on *Colacium* sp. in plankton from Frains Lake, Washtenaw County, Michigan, March–June, September–October, 1954; and March–June, 1955.

So far as is known this is the first report of a fungus parasitizing species of *Colacium*. The latter, a member of the Euglenophyta, is epizoic on copepods, cladocerans and other zoöplankters.

The method of development of this chytrid on the host is as follows: The spherical zoöspore encysts only on the gelatinous stalk of the alga. Upon germination a tube is produced which grows through this stalk and penetrates the host cell proper (FIG. 1 B, C, D). Within, a branched rhizoidal system is formed which after a short time causes the contents of the host organism to shrivel and to turn brown. Meanwhile, the zoöspore cyst expands to form a broadly ellipsoidal zoösporangium 8 to 11.5 μ wide by 11 to 17.5 μ long (FIG. 1 A). Its contents are at first granular and interspersed with fine oil droplets which eventually coalesce to form at maturity numerous refractive globules of uniform size. The zoöspores are then delimited and subsequently their discharge is effected by the deliquescence of the entire upper half of the sporangial wall (FIG. 1 F, G). The liberated zoöspores oscillate for a few seconds *en masse* and then swim away individually in the medium. They are spherical, 3 μ in diameter, with an eccentric oil globule and a posteriorly directed flagellum, 15 to 16 μ long. The resting spore has not as yet been observed.

In its manner of growth and reproduction this organism resembles *Hapaloptera piriformis* Fott (**1942**), which is parasitic on the sessile unicellular green alga, *Characium ancora* (G. M. Smith) Fott. The zoöspore of *H. piriformis*, however, encysts at any place on the host cell wall, whereas in the present species it is always found to encyst on the gelatinous stalk of the alga. Indeed, penetration of the host cell proper is not achieved until the germ tube has grown through the gelatinous material of the algal stalk. Furthermore, in *H. piriformis* the entire sporangial wall deliquesces rather than only the upper half as in *Rhizophydium pelagicum*. Other differences are apparent. For example, the rhizoid of *Hapaloptera* consists of a fine unbranched thread in contrast to the coarser, branched, rhizoidal system of *Rhizophydium pelagicum;* the sporangia are pyriform and are borne on a slender stalk in Fott's species, whereas in *Rhizophydium pelagicum* they are ellipsoidal.

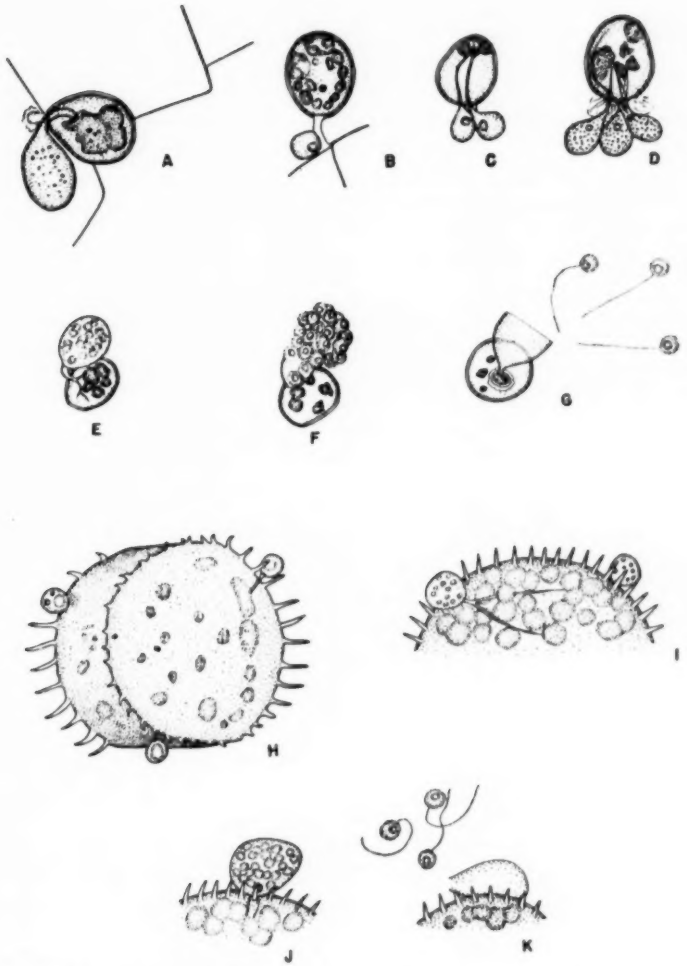

FIG. 1. A–G. *Rhizophydium pelagicum* on *Colacium* sp. A. Mature sporangium on host, showing algal cell epizoic on a copepod. B–E. Stages in the development of the thallus. F–G. Stages in the discharge of zoöspores. H–K. *Rhizophydium horizontale* on *Stephanodiscus* sp. H–J. Stages in the development of sporangia on host. K. Discharged sporangium, showing zoöspores just released. All figures × 860.

Rhizophydium pelagicum also resembles *Rhizophydium clinopus* Scherffel (**1930**) in that discharge is effected by the deliquescence of the upper half of the sporangial wall. In Scherffel's species, however, the sporangium is distinctly and characteristically obpyriform, its rhizoids are unbranched, and it parasitizes only diatoms.

The present fungus is placed in the genus *Rhizophydium* because of its inoperculate sporangium, the development of the sporangium by uniform enlargement of the zoöspore cyst, and its branched rhizoidal system.

Rhizophydium horizontale sp. nov. (FIG. 1, H–K)

Sporangium sessile, ovoideum, membrana levi, diametro 7–10 μ, 11–15 μ longum, plerumque procumbens, longo axi parallelum cellulae hospitis. Systema rhizoidale simplex vel sparsim ramosum. Zoösporae numerosae, sphaericae, 3–3.5 μ diametro, globulo uno refractivo, 1.5 μ diametro, flagello postico 13 μ longo, praeditae; ex poro singulo apicali emissae. Sporae perdurantes non observatae.

Sporangium sessile, ovoid, smooth-walled, 11–15 μ long by 7–10 μ in diameter, usually procumbent, with its long axis parallel with the surface of the host cell; rhizoidal system unbranched or sparingly branched; zoöspores numerous, spherical, 3–3.5 μ in diameter, with a single eccentric refractive globule, 1.5 μ in diameter, and a posterior flagellum 13 μ long, escaping through a single apical pore; resting spore not observed.

Parasitic on *Stephanodiscus* sp. in plankton from the Huron River, Washtenaw County, Michigan, December, 1953, and from Portage Lake, Washtenaw County, Michigan, January, 1955.

Only two aquatic Phycomycetes have thus far been described as parasitic on members of the centric diatom *Stephanodiscus*. *Podochytrium cornutum* Sparrow (**1951**) was found on *Stephanodiscus niagarae* Ehr. in Wisconsin, and a fungus resembling *Zygorhizidium planktonicum* Canter was described by Canter (in Canter and Lund, **1953**) on *Stephanodiscus astraea* (Ehr.) Grun. from England. The present parasite, a member of the genus *Rhizophydium*, was found on a species of *Stephanodiscus*. It was not present on diatoms belonging to other genera found at these localities at the same time.

In the developmental sequence of this chytrid, the zoöspore encysts on the diatom frustule and sends a penetration tube through the siliceous cell wall of the host. Invasion is not restricted to any particular place on the host cell, although it is possible that entrance may be gained through the areolae. Further growth of the germ-tube produces the endobiotic rhizoidal system which consists of an unbranched or once-branched tapering tube (FIG. 1, I). Meanwhile, the zoöspore cyst

gradually expands into an ovoid sporangium, 11 to 15 μ long by 7 to 10 μ in diameter, whose long axis is usually parallel with the surface of the upper valve wall although occasionally it may be slightly oblique (FIG. 1, J, K). The contents of the sporangium are at first granular with numerous refractive droplets which coalesce at maturity into fat globules, 1.5 μ in diameter. These subsequently become the oil globules of the zoöspores. The latter, after cleavage, are 3 to 3.5 μ in diameter with a posteriorly directed flagellum, 13 μ long. Following delimitation of the zoöspores, dehiscence occurs by the deliquescence of a discharge papilla located terminally on the sporangium, at which time the spores are discharged singly (FIG. 1, K).

The present species most closely resembles *Rhizophydium asymmetricum* (Dangeard) Minden (**1915**) in the nature of the sporangium. Although it is often tilted in *Rhizophydium horizontale*, with the apical papilla slightly oblique as in *R. asymmetricum*, the zoösporangium more frequently lies with its long axis parallel with the upper valve of the host. Other differences between the two are to be found in the nature of the rhizoidal system and in the host. The present species has unbranched or once branched rhizoids, whereas in *R. asymmetricum* the rhizoidal system consists of branches which arise from a main axis. *Rhizophydium horizontale* parasitizes a centric diatom, *Stephanodiscus* sp. in contrast to *R. asymmetricum* which is parasitic on a member of the Xanthophyceae, *Tribonema bombycina* (C. A. Ag.) Derbés & Solier. Because of these differences it is considered distinct.

?RHIZOPHYDIUM sp. on *Rhizosolenia eriensis* H. L. Smith (FIG. 2, A–D)

Among the numerous parasites which Canter has found infecting members of the phytoplankton in England is a chytrid described as living on the centric diatom *Rhizosolenia eriensis*. An organism parasitizing this diatom was found in Douglas Lake, Cheboygan County, Michigan, in June, 1954, and in Portage Lake, Washtenaw County, Michigan, in February, 1955. It is unquestionably the same fungus discussed, but unnamed by Canter (in Canter and Lund, **1953**). Both have spherical sporangia, 4 to 6.5 μ in diameter, and rhizoids which are branched distally (FIG. 2, B). Further, their method of host penetration is the same. In this process the germ tube grows along the outside of the host wall until it is opposite a chromatophore, at which point invasion of the cell occurs (FIG. 2, A). Growth continues until penetration of the chromatophore is achieved, at which time the germ tube

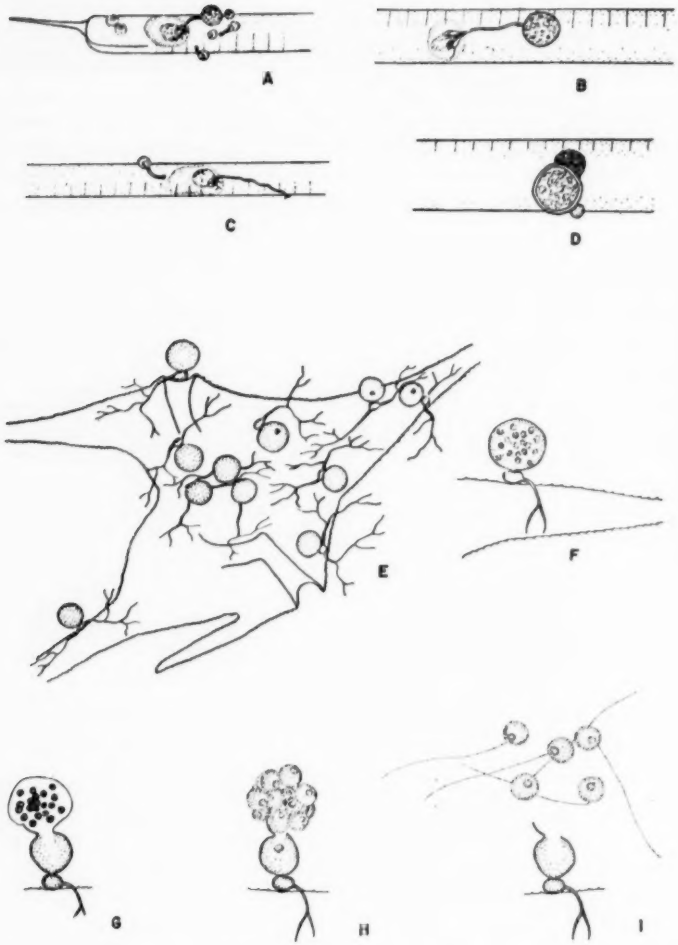

FIG. 2. A–D. *Rhizophydium* sp. on *Rhizosolenia criensis*. A. Developing thalli on host. B. Sporangium on host. C. Developing thallus on left; cup-like remains of discharged sporangium on host, showing terminating stalk and rhizoids. D. Sexually formed resting spore with adnate male thallus. E–I. *Amphicypellus elegans* on *Ceratium hirundinella*. E. Thalli on theca. F. Mature sporangium on theca. G, H. Stages in the discharge of the operculate sporangium. I. Empty sporangium with zoöspores dispersing. All figures × 860.

produces branched rhizoids. Subsequently, a change occurs in the appearance of the chromatophores, which now shrink and turn yellow-brown. Zoöspore discharge was not observed in the English material. Some information has been obtained concerning this process in the present investigation. There is strong evidence that dehiscence is achieved by the deliquescence of the entire sporangial wall. This is based on the fact that numerous distinct rhizoids have been observed, each bearing only a small cup-shaped structure at the distal end of the epibiotic portion (FIG. 2, C). It is very probable that this is what remains of the basal part of the sporangium after dissolution of the wall during zoöspore discharge.

Further information on this interesting chytrid concerns the resting spore, which was not seen by Canter. This is apparently formed after a process of sexual reproduction involving the fusion of male and female thalli. It is probable that the zoöspore which will function as a male encysts directly on the female thallus. Following adnation of the two, the contents of the male thallus move into the receptive cell. The female thallus is at first thin-walled, not unlike a zoösporangium in appearance, and its contents bear numerous refractive droplets. Furthermore, its rhizoidal system is identical with that found on the asexual reproductive structure. Subsequent to the passage of the male contents into the female cell, there is a thickening of the wall of the receptive thallus so that at maturity the resultant resting spore has a smooth, thick wall (FIG. 2, D). The fully mature resting spore is spherical, contains numerous refractive globules of unequal size, and is from 7 to 10 μ in diameter. Germination has not as yet been observed.

The present organism is probably most closely related to *Rhizophydium cyclotellae* Zopf (**1887**). Similarities of the two are to be found in the deliquescence of the wall of a spherical sporangium, the formation of delicate rhizoids from a main axis, and in the somewhat slight relationship of host organisms. *R. cyclotellae* infects the centric diatom *Cyclotella*, whereas the present fungus is parasitic on *Rhizosolenia*, also a member of the Centrales.

AMPHICYPELLUS ELEGANS Ingold (FIG. 2, E–I)

Ingold (**1944**) described from preserved material from England a saprophytic chytrid, *Amphicypellus elegans*, which was found growing on the theca of two dinoflagellates, *Ceratium hirundinella* (O. F. M.) Schrank and *Peridinium* sp. It has since been reported only by Canter (**1951**). This same species was found on *Ceratium hirundinella* at

Frains Lake, Washtenaw County, Michigan, in the fall of 1954, the spring and summer of 1955, and in the spring of 1956.

In the developmental sequence of this chytrid, which has not heretofore been followed, the encysted zoöspore on the host theca first produces a basal bud which enlarges into an epibiotic ovoid apophysis, 3.5 to 4.5 μ broad by 2 to 3 μ high. Shortly after the formation of this apophysis two lateral rhizoids are usually produced (FIG. 2, E), although occasionally there may be one (FIG. 2, F, G, H, I) or sometimes even three or four. Both apophysis and rhizoidal system are epibiotic except for the tips of the rhizoids which penetrate the host wall. The zoöspore cyst ultimately enlarges to form a spherical zoösporangium which is 6 to 10.5 μ in diameter. Its protoplasm bears granules and fat droplets which coalesce and round up during maturation to form several oil globules of uniform size. Sporangial discharge is initiated by the dehiscence of an operculum followed by the extrusion of the oil globules and their accompanying protoplasm into a vesicle produced at the orifice of the sporangium (FIG. 2, G). After the protoplasmic mass has discharged into the vesicle, ten to twenty zoöspores are simultaneously delimited (FIG. 2, H). These then begin to oscillate and upon deliquescence of the vesicle are finally liberated (FIG. 2, I). They are spherical, 3.5 to 4.5 μ in diameter, with an eccentric oil globule, and are posteriorly uniflagellate.

The present observations have confirmed Ingold's (**1944**) supposition that *Amphicypellus* is operculate. Inasmuch as the description of his new genus was derived solely from preserved material, the nature of zoöspore discharge could not be determined by him. The observation of operculate sporangial dehiscence in the Michigan material, therefore, is an exceedingly important point in determining the precise relationships of *Amphicypellus*.

Because of the new information gained on the manner of sporangial dehiscence it is now possible to compare *Amphicypellus* with closely related genera. The operculate genus *Chytriomyces*, described by Karling (**1945**), bears a close resemblance to *Amphicypellus*, but several significant differences exist which separate the two. Of these, certain features of the apophysis and rhizoids are of importance. The apophysis, where formed, of *Chytriomyces* and its rhizoidal system are endobiotic, whereas in *Amphicypellus* they are distinctly epibiotic with only the tips of the rhizoids penetrating the substrate. *Chytriomyces* is not consistently apophysate and particularly is this so in the type species, *C. hyalinus*. The apophysis is entirely lacking in two of Karling's other species, *Chytriomyces appendiculatus* (**1947**) and *C. lucidus* (**1949**), and

is also absent in *C. spinosus* (**1947**) and *C. tabellariae* (Schröter) Canter (**1949**). In these species the rhizoids, with one to several main axes, arise directly from the base of the sporangium. Contrasted with these chytrids, of several hundred individuals of *Amphicypellus elegans* observed, all were found to be apophysate. Furthermore, in *Chytriomyces*, rhizoids may arise from any position on the apophysis, whereas they are always produced laterally in *A. elegans*. Although both genera form vesicles upon zoöspore discharge, there is a difference in the location of zoöspore cleavage. Thus, in *Chytriomyces* the zoöspores are completely delimited at discharge, whereas in *A. elegans* there is no final cleavage of cytoplasm into zoöspores until after the contents of the zoösporangium have been extruded into the vesicle.

Since as yet no resting spore has been observed in *Amphicypellus* its precise relationship to other chytrids cannot be determined with certainty. Furthermore, when the nature and position of the resting spore of *Amphicypellus* is found, we may be able to give a more critical evaluation of *Chytriomyces* (where it is asexual and epibiotic) than we can at present.

In addition to the two foregoing taxa several species were found which have been hitherto unrecorded from the United States.

SEPTOLPIDIUM LINEARE Sparrow

In *Synedra* sp., Portage Lake, Washtenaw County, Michigan, January, 1955.

This is the first time this fungus has been noted since its description by Sparrow (**1933**) in England.

RHIZOPHYDIUM PLANKTONICUM Canter

Parasitic on *Asterionella formosa* Hass., Douglas Lake, Cheboygan County, Michigan, June, 1954, and in Base and Portage Lakes, Washtenaw County, Michigan, November, 1954.

So far as is known this is the first report of the occurrence in the United States of this parasite of a very important phytoplankter.

RHIZOPHYDIUM FRAGILARIAE Canter

On *Fragilaria crotonensis* (Edw.) Kitton and *Fragilaria capucina* Desmazières, Portage Lake, Washtenaw County, Michigan, March, 1955.

Besides being a new record for the United States this fungus has not been previously reported on *Fragilaria capucina*.

RHIZOSIPHON ANABAENAE (Rohde & Skuja) Canter

Parasitic on *Anabaena planktonica* Brunnthaler, Frains Lake, Washtenaw County, Michigan, June through July, and September through October, 1955.

Not previously reported on *Anabaena planktonica* and hitherto unreported in the United States.

POLYPHAGUS RAMOSUS Jaag & Nipkow

On *Gomphosphaera lacustris* Chod., Douglas Lake, Cheboygan County, Michigan, June, 1954.

Not previously reported on *Gomphosphaeria lacustris* and hitherto known only from Switzerland.

Although details concerning zoöspore discharge are lacking, highly distinctive stages in development of the thallus indicate that it is *Polyphagus ramosus*.

ENDOCOENOBIUM sp.

On *Sphaerocystis schroeteri* Chod., Whitmore Lake, Livingston County, Michigan, May 23, 1955.

Although only two individuals were observed it was considered to be so unmistakably a member of this most interesting and rare genus as to be worthy of mention. In spite of the fact that the zoösporangium was not seen, the undulate thallus or prosporangium with the sac-like rhizoidal outgrowth and the persistent zoöspore cyst were present and are precisely like young developmental stages figured by Ingold (**1940**).

SUMMARY

Two new species are described from two lakes and a river in Washtenaw County, Michigan, namely, *Rhizophydium pelagicum* and *Rhizophydium horizontale*, parasitic on *Colacium* sp. and *Stephanodiscus* sp., respectively. Further details in the life history of *Amphicypellus elegans* and of a species previously noted by Canter as parasitic on *Rhizosolenia eriensis* from England are given. New records for the United States are listed for the following taxa: *Septolpidium lineare*, *Rhizophydium planktonicum*, *Rhizophydium fragilariae*, *Rhizosiphon anabaenae*, *Polyphagus ramosus*, and *Endocoenobium* sp.

The author wishes to express his gratitude to Professor F. K. Sparrow for his criticism during the course of this work and in the

preparation of this paper, and to Professor H. H. Bartlett of the Botany Department, University of Michigan, for help with the Latin diagnoses.

BOTANY DEPARTMENT
UNIVERSITY OF MARYLAND
COLLEGE PARK, MARYLAND

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MYCOLOGICAL TAXONOMY AS RELATED TO PRACTICAL PROBLEMS IN MICROBIOLOGY [1]

G. W. Martin

In experimental work with microorganisms, the necessity for the precise designation of the species involved is very generally recognized. A large proportion of the published papers in this field bear evidence that the authors have been aware of this requirement and have endeavored to comply with it. Nevertheless, it is easy to find examples in which neglect of such precision has detracted from the usefulness of the results and has sometimes seriously affected their significance. Some years ago a study of the nutrition of molds included in the experimental series one species referred to only by a misspelled generic name, one designated as "a wild blue-green mold," another as "a wild light brown mold," with nothing more to suggest what the latter two may have been. More recently, of 12 species of "Basidiomycetes" cited as experimental material, one was listed as *Morchella crassipes*. These are only two of many instances I have noted over a period of years.

There are several ways of insuring a high degree of precision in this respect. In institutions where there are teams of workers concentrating on one problem, it is not unusual for one of the members of such a team to be a competent mycologist, or, if there is not such a mycologist on the team, there may be one available in the same institution, or a specialist elsewhere who can be consulted. Many culture collections are maintained, such as that of the well-known center at Baarn, Holland, and the National Type Culture Collection in Washington, from which authentic cultures may be purchased at a moderate price, and these facilities are frequently used. All of these methods have great usefulness; all carry with them certain problems.

It is not as easy as might be supposed to secure the services of a competent general taxonomic mycologist, one, that is, who is familiar with the whole range of fungi. The current, and wholly understandable, emphasis on experimental work has naturally tended to focus the interest and time of younger people in training on such phases of

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mycology. As a consequence, relatively few have had opportunity to acquire the broad basis of study and experience requisite for good taxonomic work and they are apt to be largely unfamiliar with the flood of recent and very largely uncollated work, much of it from abroad, which must somehow or other be incorporated into a complete system. It is less difficult to find one who is familiar with a limited group of fungi and, within his limitations, his services may be invaluable—more so, in certain cases, than if he attempted to cover a wider field. It takes most of one's time to be a really competent authority on a few such genera as Penicillium, Aspergillus or Fusarium, or such groups as the Pythiaceae or the mucors, and it is fortunate that such men are available. But such a specialist may easily go astray when dealing with fungi outside the limits of his special interest, just as the general mycologist will do well to refer material in the more difficult groups to the specialist. But a competent mycologist, working as one of a team, will know what he can do himself and what he should try to refer, in particular cases, to the specialist.

Specialists are usually busy men, practically always with more material at hand than they can study adequately. Many of them are teachers, able to devote to research only such time as can be salvaged from the immediate demands of class work and ancillary academic duties. However willing they may be, it is unfair to expect them to neglect research for an undue amount of routine determination. The traffic, however, is by no means a one-way affair. Even routine examination of common and easily determined species often yields significant information concerning distribution, variability and similar matters which are important in taxonomic judgments. And the species which offer greater difficulty and take correspondingly more time for study may often be most rewarding in terms of results, provided always that somehow or other the time can be found for adequate study. The tone of the letters sent asking for determinations is often very flattering, contriving to convey the impression that the service required is, to the person addressed, a very simple matter. Sometimes it is, but in many cases it involves time-consuming culture work, careful sectioning or extensive bibliographical search. Suppose a taxonomist were to send a dozen carefully named cultures to a physiologist asking him for full details about their nutrient requirements. Here, too, sometimes the answer would be readily available; more often it would involve a complicated series of experiments. The comparison, while not wholly fair, is not completely inapplicable.

Securing a standard culture from an authoritative source is a frequent and commendable procedure. It is not, however, without its

hazards. Many fungi, after long years of culture on media which are not particularly suited to them, fail to exhibit either the morphological or physiological features which are supposed to be characteristic of them. This is so widely recognized by taxonomists that it is becoming a common precaution to deposit dried cultures in herbaria to serve as documentation in case the cultures distributed fail to maintain the described morphological features. For many fungi, lyophilization is effective, but not all fungi are amenable to that treatment. Even when a good typical standard culture is secured, there are further pitfalls. I recall one laboratory where a culture of *Chaetomium globosum,* secured from an unimpeachable source, had been tested as a cellulolytic agent. The results were completely negative. So far as the experience of that particular laboratory was concerned, *Chaetomium globosum* did not attack cellulose. They had tested it carefully, and they knew! Examination of the cultures they were using showed that the Chaetomium had been entirely replaced by *Rhizopus stolonifer,* and the experimenters did not know the difference. In another laboratory, a fungus used in tests had been identified as *Mucor mucedo;* it proved to be the same ubiquitous Rhizopus.

Perhaps the fungus I have referred to as *Rhizopus stolonifer* would have been more familiar to some had I called it *Rhizopus nigricans.* In this instance, no confusion could result whichever name were to be used in published work. But this leads to consideration of a criticism of taxonomic work often made by those who use organisms for experimental purposes, namely, that the constant changes in nomenclature constitute in themselves a prolific source of confusion. This is true, but I am afraid it is an inevitable result of our increasing knowledge of the fungi. The system of classification in common use today was established in substantially its present form nearly three-quarters of a century ago. It is no more surprising that it should be inadequate to encompass our current knowledge of the fungi than that the chemistry and physics of that time do not answer present day needs. Yet chemists and physiologists who would not think of basing their work on the theories and techniques of the 1880s or even of the 1920s, feel and express a sense of grievance when a taxonomist replaces a familiar name with another and, at first sight, unfamiliar one.

Certainly, I do not contend that all name changes which are proposed are desirable or even justifiable. But so long as our knowledge of the fungi is increasing we are bound to discover that some names in common use are incorrectly applied; that some genera, as defined in the standard references, embrace widely divergent species; that many genera and species, founded on what seemed at the time adequate grounds, can no

longer be maintained as distinct; that families and larger units in current use no longer reflect what recent study suggests as true relationship. This picture is true of every group of organisms, more noticeably, of course, of those which possess economic significance, partly because so many people have to make use of the taxonomic systems applying to them and partly because they are apt to be more extensively studied than those of lesser economic importance.

Some name changes are occasioned by modification of the rules of nomenclature; many more are due to stricter application of the rules. It is regrettable that these should seem necessary, but it must not be forgotten that one of the primary objectives of the rules is to ensure as high a degree of ultimate stability in names as is consistent with necessary latitude to permit adjustment to increasing knowledge. Despite statements to the contrary, and specific instances which may be cited, it is my opinion that the general movement is toward greater stability.

The increasing interest on the part of experimental workers in the imperfect fungi may make it expedient to comment on a few of the problems which arise in the taxonomic approach to that group. Not so many years ago it was customary, in mycological texts, to dismiss them in a few words as representing a category which would soon disappear as they were shown to be stages of fungi belonging to other groups. As recently as 1949, an excellent text on mycology devoted only a little over one page, out of a total of over 400, to a discussion of these forms. I have not made a count, but I should estimate that well under one-half of the known species of imperfect fungi have known perfect stages. In some cases we can infer with a fairly high degree of accuracy what the perfect stage, if it were found to exist, would be like; in a larger number of cases such an inference would be much less certain; in a considerable number of cases basis for even a plausible guess is lacking. It is quite possible that a number of the imperfect fungi have lost whatever perfect stage they once had; it is equally possible that some never had one.

The action of the Stockholm Congress authorizing the use of form-generic names and specific epithets of imperfect fungi after the perfect stages are known, embodied in slightly modified form in Article 59 of the current Code, illogical as it is, has been of immense practical service, permitting complete and usable treatments of important imperfect genera on a unified basis. But it still remains true that the present system of classification, based on Saccardo's scheme, is rapidly becoming more and more inadequate. A few familiar examples may be cited to illustrate this. So common a fungus as *Aspergillus niger*, and other species of

the same genus with dark spores, must be placed in the Moniliaceae, although adherence to the basic key character would send one to the Dematiaceae. The genus is so well known that by common consent we disregard the key character. But what about some of the less well-known genera? Botryodiplodia, in culture, produces in abundance large, 1-celled, colorless, viable spores suggesting Macrophoma. Later—sometimes two or three weeks later—the spores become dark, as in Sphaeropsis or Dothiorella. Only at complete maturity are the dark, septate spores of the Diplodia type produced. The basic characters—clustered pycnidia and, in culture, a stalk-like stromatic base—are subordinated in the keys to the quite incidental spore characters.

In a broader sense, how sharp is the distinction between an open pycnidium and a compact acervulus or between an acervulus and a sporodochium? How constant are such structures in nature and, even more important, in culture? In our current keys, to find Pestalotia, one would have to say the spores are borne in an acervulus and it would therefore have to be looked for in the Melanconiaceae. Many species grow readily in culture and then, on a wide range of common media, they behave like typical members of the Dematiaceae. There is abundant reason to believe that Stachybotrys, with clumped free spores, and Memnoniella, with catenulate spores, are closely related, yet in the keys they are widely separated. Many suggestions have been made for revising Saccardo's system, the most promising being that of Hughes in 1953, but neither Hughes's system nor any other has yet reached the stage where it can be widely accepted and adapted for practical use. But the change is coming and it may be well to be prepared to recognize it when it does.

The great majority of our fungous species are based on material found growing naturally on various substrata in the field. With the increase in cultural work, however, the proportion of genera and species based on cultural studies is constantly increasing. That is inevitable and proper. But it must be remembered that a great many of our commonly used media are far too rich in nutrients to give a representative picture of what the same fungus might look like if it were to appear in nature. For many years I have been advocating, *for taxonomic purposes*, the use of culture media of low nutritive content. In a large number of instances, such a medium will give a truer picture of the comparative morphological characters of the fungus than will its growth on richer media. This is not intended to deprecate in any way the use of carefully formulated and often very rich media for fungi with special requirements, or in experiments involving nutritional studies; it has to do strictly with the taxonomic approach. One illustration will show

what I mean. Some years ago I received from the tropics a large number of cultures. In the tubes as received they formed glutinous masses, yeast-like in appearance, but much tougher than any yeast colony, with no sporulation, but with a bewildering array of swollen, lobate hyphal structures. When transferred to ordinary laboratory media they proved to be common molds, mostly species of Aspergillus and Penicillium. Inquiry revealed that they had been sent on tubes of one of the richer Sabouraud formulas secured from a local hospital. Such an experience makes one wonder just how much significance is to be attached to the curious, and strikingly similar, abortions illustrated in so many papers on medical mycology.

In this age of automation, it is not surprising that various proposals have been made for using punch-cards in the determination of fungi. For special purposes and where a narrow range of species is involved, it is conceivable that these might prove to be useful and effective. Any attempt to apply them to the fungi as a whole is far less promising. Any such scheme must be based on a system which, as I have already indicated, is falling apart by reason of its inadequacy. Its general adoption would tend to freeze out-dated concepts and would be a serious deterrent to efforts to improve our classification.

I am sure we can all agree on the necessity for precise designation of experimental organisms. What I have been saying is essentially a plea for recognizing that such precision can best be attained, in the long run, by accepting taxonomy for what it is, not a finished product, but an actively changing and vigorously growing part of our knowledge. I have pointed out that as far as the fungi are concerned the published systems are antiquated and much newer information has not yet been fitted into a comprehensive and generally accepted framework. To acquire the necessary background and an adequate understanding of the later developments is a full-time job. If experimental workers can be made to realize this and to accept the work of the taxonomist as a legitimate and necessary part of the approach to the problems they are trying to solve, it would, in my opinion, be to the mutual advantage of both experimentalists and taxonomists. It might also be one way of impressing upon the taxonomists the necessity for understanding the methods and results of experimental study and of applying such of the results as seem pertinent to their own problems. We still have much to learn from each other.

DEPARTMENT OF BOTANY
STATE UNIVERSITY OF IOWA
IOWA CITY, IOWA

NEW GENERA OF FUNGI. VIII. NOTES CONCERNING THE SECTIONS OF THE GENUS MARASMIUS FR.

ROLF SINGER

Since Kühner's studies of the anatomy of *Marasmius* and the iodine reactions and the metachromatism of its tissues, a few minor additions to the knowledge of this genus have been published. Because there is only a very limited number of species of this genus in Europe, a large sample of the world flora was tested by the author of the present paper in order to find out whether Kühner's classification—founded exclusively on European material—can serve as a basic arrangement for the species of this genus (see Lilloa **22**: 321–340. 1951). The answer was affirmative, and consequently Kühner's classification was accepted not only in the paper cited but in the Singer & Digilio "Pródromo" of the Argentine agaric flora (Lilloa **25**: 183–217. 1952). What was added to Kühner's scheme was merely the integration of the system by addition of such typically tropical elements as the section *Apus* Sacc. (strongly eccentric to lateral or pendulous species with inamyloid trama and hymeniform epicutis), the section *Fusicystides* Sing. (pleurotoid, with non-hymeniform epicutis and characteristic cystidia), and the section *Spinosissimi* Sing. (totally aberrant in basidiospore formation and covering layers) further discussed. On the other hand, several scores of species not occurring in Europe entered the existing scheme quite smoothly, and only recent special studies have revealed certain difficulties. These difficulties arise from the unsatisfactory delimitation of the sections *Hygrometrici* and *Rotulae*, and the existence of two species which do not fit in the existing set of sections: *M. concolor* sensu Sing. & Digilio, non Berk. (for which are proposed the new name *M. neosessilis* Sing.[1] and the section *Neosessiles* Sing.[2]), and *M. inaequalis* Berk. (for which is proposed a new subsection in a forthcoming paper).

[1] **Marasmius neosessilis** Sing. sp. nov. Pileo armeniaco, 1–2.5 mm lato; lamellis albis, tribus vel quatuor; stipite nullo; sporis 9.5–10 × 4–4.8 μ; epicute pilei hymeniformiter disposita, ex elementis granulosis vel diverticulatis efformata; hyphis fibulatis, amyloideis (pseudoamyloideis). Ad ramulos emortuos, Cataratas del Iguazú, Misiones, Argentina, leg. *Singer et Digilio M84*, TYPUS (LIL).—A description in Spanish was given in Lilloa **25**: 190. 1952, under the name "*Ma-*

The problem of the delimitation of the *Rotulae* has been solved in a simple and, I believe, satisfactory manner in a paper published at about the same time as those cited above (Dennis, Brit. Myc. Soc. Trans. **34**: 414–419. 1951). Dennis worked on the *Marasmii* and related groups of northern South America (Trinidad and Venezuela), and based his interpretation of the section *Rotulae* exclusively on the presence of a collarium ("collar") formed by the lamellae around the apex of the stipe. Although he does not say so, his classification neglects, in this instance, the basic chemical character used by Kühner, the presence or absence (and the degree and localization) of the Melzer reaction in the trama, and the shape and arrangement of the epicuticular elements (broom cells, éléments en brosse). This results in a much more natural arrangement than any other modern approach. I have arrived at this opinion by observing that in *M. multiceps* Berk. & Curt. and related species of the *Rotulae* there is a tendency, more distinct in age, towards the loss of truly hymeniform cell arrangement in the epicutis of the pileus, whereby eventually, in many caps, a structure is formed belonging, according to the definition, to the *Androsacei*-type rather than to the hymeniform type of the typical *Rotulae*. Even more difficult is the separation of the species by the amyloid reaction of the trama. A revision of the stirps *Graminum* (*M. graminum* and allied forms) showed that there is a variation from negative to weakly positive Melzer reaction in the trama of the pileus and hymenophore within this single group of varieties, an extreme form of which I formerly considered an autonomous species, *M. culmisedus* Sing. in Sing. & Digilio. Furthermore, I have observed that in all these borderline cases the reaction of the tissue of the stipe is strictly positive while in other groups even the tissue of the stipe or the interior of the rhizomorphs fails to react with the iodine solutions when treated in the routine manner. I have also observed that by treating the preparation first with concentrated hydrochloric acid, a slow positive reaction can be provoked in some cases where ammonia hydrolysation does not achieve the same result. A similar case has been discussed by me in *Mycena* (Lilloa **22**: 353. 1951).

The collarium, on the other hand, appears to be, at least in *Marasmius* in the narrower sense but not in *Marasmiellus*, a reliable character. Only in the stirps *Graminum* and in occasional specimens of

rasmius concolor Berk. (?)." An analysis of the type, however, has shown that this latter species belongs in *Marasmiellus*.

[2] *Marasmius* sect. **Neosessiles** Sing. sect. nov. A sectione *Apode* Sacc. differt tramate amyloideo. TYPUS: *Marasmius neosessilis* Sing.

M. griseoviolaceus there exists a rather indistinct but (especially under a dissecting microscope) still visible form of collarium which not only shows the origin of this strange formation but serves to extend the definition of the term. Obviously the difference in the degree of the iodine reaction between the tissues of the stipe on one hand, and of the pileus and hymenophore on the other, expresses a difference in quality of the tissues which is supplemented by a difference in hyphal arrangement. These differences lead to an easy separation of the strictly parallel hyphae of the apex of the stipe from the inner (rear) portion of the hymenophoral tissue which originally touches the stipe tissue at a right angle without being intimately interwoven, because the hymenophoral trama originates not from the tissue of the stipe but from that of the pileus. As the pileus expands, the hymenophore is pulled off intact. The joining of the inner ends of the lamellae seems to be caused by a certain pressure during the primordial stage of the carpophores (which are hemiangiocarpous), whereby the inner ends of the lamellae are pressed against the stipe. In some specimens of *M. graminum*—a good example is the type specimen of *M. pruinatus* Berk. & Curt.—we can still observe between the collarium proper and the apex of the stipe hyphal connections which look like a small cortina under the binocular; in others, the collarium is so closely appressed to the apex of the stipe that in certain circumstances, especially in specimens developed under very wet conditions, a spacial separation is not achieved. Such cases of not completely free collarium—especially since they are exceptional in the species where they occur—should be understood as extreme forms of the collarium. On the other hand, in sections defined by the absence of a collarium, even such extreme cases are not observed, except in *M. anomalus* Lasch, which is sometimes called "subcollariate." Here, however, the hymenium is merely sharply differentiated from the apex of the stipe, but as far as I am aware no tendency toward effective separation can be observed in any specimens. The correlated characters, separating *M. anomalus* from the *Rotulae*, are additional evidence that such cases should not be understood as belonging to the collariate species. With this understanding, one may say that all truly collariate species have insititious stipe and in the young stages hymeniform epicutis broom cells.

This does not mean that the anatomy of the epicutis and the chemical behavior of the hyphae are now abandoned as diagnostic characters. It is well known that, even within the same genus, a single character can never be assumed *a priori* to have the same weight and significance in all groups. While in the *Rotulae* we use these characters, especially

the chemical one, as specific, and in the stirps *Graminum* as varietal, they appear to be as valuable as ever in the remaining sections of the genus *Marasmius*, excepting in the section *Epiphylli* where Kühner himself discovered that the amyloidity cannot be used as a sectional character, and in the section *Sicci* Sing. (Kühner's *Globularini* with epicuticular broom cells), where we know now that one species exists with inamyloid trama, *viz. M. inaequalis* Berk. & Curt. While in the section *Sicci* the division is sharp enough to permit the erection of a subsection for the aberrant species, I do not believe that in the *Rotulae* such a procedure would be justified, or even practicable.

Returning to the structure of the epicutis in the section *Rotulae*, I should like to point out another possibility of subdividing the section into two natural groups, perhaps subsections. In those species where the broom cells show a strong tendency to become irregular in age, as well as in a number of species where this phenomenon has not been seen, I have observed that the broom cells are different from the type seen in the section *Sicci;* they remind one of the dendrophyses of the genus *Favolaschia—i.e.*, they are covered on a wider area, either only on the upper quarter or third, or deeper down, with short, usually rather regularly distributed divergent spinules (cylindrical appendages), quite unlike the erect and strictly apical setulae of the typical *Sicci*. The latter type, also occurring in the section *Rotulae*, is consequently called the *Siccus*-type (from the type species of section *Sicci, M. siccus*) while the dendrophysoid type is termed the *Rotalis*-type, since it is particularly well represented in *M. rotalis* Berk. & Br. This latter structure may lend itself more easily to the breaking through of elongate hyphae which arrange themselves horizontally and are diverticulate, much in the manner of the epicuticular hyphae of *Mycena* in old specimens, whereby the whole epicutis loses, to a certain degree, its hymeniform structure.

The large section formerly called *Globulares* Kühner, consisting of two series of species which in 1951 I separated as *Globularini* and *Siccini* respectively, the former having smooth epicuticular elements, and the latter echinate ones (broom cells of the *Siccus*-type), is particularly rich in species in the American tropics, but no transition between the two sub-groups has been noted. Consequently, I separate them now as two autonomous sections, section *Globulares sensu stricto*, and section *Sicci* Sing. sect. nov.[3] Dennis (*l.c.*) goes even one step

[3] **Sicci** Sing. sect. nov.—Epicute ex elementis echinatis hymeniformiter dispositis consistente; stipite non insititio; lamellis haud collariatis. TYPUS: *M. siccus* (Schw.) Fr.

further by recognizing as *Marasmius* only species with broom cells (in other words, *Androsaceus* Pat.) while transferring all the rest to *Collybia*. The affinity of such species as *M. haedinus* and *M. niveus* is, however, obvious at sight; and the epicuticular elements of some *Sicci* show characteristic bulges, hooks, and outgrowths while, on the other hand, some *Sicci* have smooth cells in their epicutis, in addition to broom cells. By emphasizing the single character of smooth against spinulose cells, Dennis arrived at a solution which offers as an advantage the clearer separation of *Globulares* sensu stricto and *Sicci* Sing. while as a disadvantage its brings about the unjustified separation of closely allied elements of a group which we consider as belonging not to *Marasmius* but to *Marasmiellus*. Representatives of the section *Rameales* show up, in Dennis's classification, in *Marasmius* as well as in *Collybia; e.g., Marasmiellus nigripes* and *M. subingratus* are listed as *Marasmii* whereas *Marasmiellus brasiliensis* and *M. inodermeus* are transferred to *Collybia*. The obvious question is: Just how differentiated must the epicutis be (*i.e.*, how evident must the so-called *Rameales*-structure be) in order to qualify a species for entrance in *Marasmius?* In reality, considering that in the species of *Marasmiellus* the diverticulation of the epicuticular cells is quite different from that in the *Sicci*, or even in the *Androsacei*, and that the structure of the epicutis is invariably correlated with non-amyloid trama, we arrive at the conclusion that *Marasmiellus* must be excluded from the *Globulares-Sicci* complex, or, for that mater, from *Marasmius* proper; *Marasmiellus* is much closer to *Micromphale* and *Collybia* than to *Marasmius*. By this exclusion we avoid systematic arrangements which, in the author's opinion, are definitely untenable, such as the creation of an enormously large and heterogeneous genus *Collybia* (arriving thus at an almost mutilated, small genus *Marasmius*), as has been attempted by Dennis, or the creation of an enormously large and heterogeneous genus *Marasmius*, at the expense of an almost mutilated genus *Collybia* which remains without *Collybia dryophila* and its allies, a solution proposed by Kühner & Romagnesi. The question whether or not *Marasmiellus* can be separated sufficiently from the genus *Collybia* arises only indirectly, since the present paper deals with *Marasmius* sensu Kühner (minus *Rameales* and *Micromphale*) and Singer (1951). I may, however, mention that, in my opinion, arising from the knowledge of a much larger number of species than are accounted for by European authors, *Marasmiellus* sensu str. (consisting of the sections *Rameales, Calopodes,* and *Pseudoconidiophori*, without *Hemimycena* and *Gerronema*) can coexist with *Micromphale* and *Collybia;* thereby all species without di-

verticulate hyphae in the epicutis of either pileus or stipe and without insititious stipe enter *Collybia*, and those without gelatinized portions of the cuticular layer and without rhizomorphs enter *Marasmiellus*. Students who wish to return to the Friesian diagnostic character, the reviving and tough context of *Marasmius*, in order to separate the genus from related ones, do not pay attention to the undeniable fact that toughness and reviving are relative characters, observed not only in related groups but rather at different levels of the same genus in different degree, and if the world flora instead of the European flora, is taken into account, are not restricted to *Marasmius*. Such genera as *Trogia*, *Nothopanus*, *Collybia* p.p., *Xerula*, *Gerronema* p.p., *Crinipellis*, and *Xeromphalina*, to name only the centrally stipitate and agaricoid ones, are also tough and more or less reviving, and still they are not closely related with *Marasmius*. On the other hand, some tropical species of *Pseudohiatula*, a genus claimed by some to be too close to *Marasmius* sect. *Alliati*, are clearly fleshy-putrescent, and not tough at all. The only difficulty arising from the separation of *Marasmiellus* on anatomical grounds hides in the observation first made when examining *Marasmiellus subfumosus* (Speg.) Sing. (*Collybia subfumosa* Speg.) concerning the development of the superficial hyphae of the pileus. In this species those start out almost smooth (with only occasional diverticules or nodes), but become distinctly diverticulate in fully mature material. Species with insititious stipe, even immature, or with permanently non-diverticulate epicutis (like *Marasmiellus candidus*) are easy to recognize and their obvious affinity with *M. ramealis* is established without any difficulty. On the other hand, species which have a fibrillose base are closer to *Collybia* proper, and here it is important to observe the structure of the epicutis on mature material so that any confusion with *Collybia* proper (epicuticular hyphae permanently smooth) can be avoided. Naturally, we have the alternative of using exclusively the macroscopic character: stipe insititious or not, whereby even species with diverticulate hyphae, probably all tropical and North American, would enter *Collybia* proper, but I have here found the anatomical character somewhat more reliable than the macroscopical one. Otherwise, it would appear that both solutions have equal merit.

The result of the preceding discussion can be summarized by saying that the limits of the genus *Marasmius*, as proposed in 1936, and then again in 1951 by this author, are still valid, and will be used further because they have been confirmed by the study of hundreds of additional, new and revised, species from various parts of the world, and the material newly analyzed (to be published in a separate paper) does not change

this conclusion. As a result of the indications given above, I am, however, convinced of the necessity of a slight revision of the infrageneric classification of *Marasmius*. The following outline still represents the Kühner system in its basic ideas, yet with certain minor although not unimportant modifications:

A. Lamellae without collarium.
  B. Stipe with strigose or fibrillose base, neither insititious nor practically absent.
    C. Epicuticular layer of the pileus formed by broom cells which are arranged hymeniformly; hyphae amyloid, rarely inamyloid.....SICCI
    C. Epicuticular layer of the pileus formed by smooth (or sometimes slightly nodose) cells which are usually arranged hymeniformly, more rarely ascendant to erect and somewhat scattered and interrupted by stretches of exposed hypodermium; hyphae amyloid or inamyloid.
      D. Hyphae completely inamyloid.....ALLIACEI
      D. Hyphae weakly and slowly to strongly and immediately amyloid.....GLOBULARES
  B. Stipe insititious or practically absent, rarely finely fibrillose and then connected with small white rhizomorphs.
    E. Epicutis of pileus formed by irregular broom cells, not hymeniform; either centrally stipitate and predominantly boreal (tropical species with distinctly amyloid trama and without pleurocystidia), or laterally to strongly eccentrically stipitate.
      F. Stipe central; cystidia none.....ANDROSACEI
      F. Stipe not central, or absent; cystidia conspicuous, fusoid; trama of pileus amyloid.....FUSICYSTIDES
    E. Epicutis of the pileus hymeniform.
      G. Hyphae inamyloid.
        H. Habit pleurotoid; stipe strongly reduced or none.....APUS
        H. Habit mycenoid.
          I. Pleurocystidia distinct, fusoid to ampullaceous; pileus usually white (at least white in marginal zone when young); stipe white (or at least white in apical zone and pale colored below), not shining; epicuticular elements usually smooth, globose, rarely appendiculate and then appendages not setulose, cells not typical broom cells, not dendrophysoid, not pigmented.....EPIPHYLLI
          I. Not combining these characters.....HYGROMETRICI
      G. Hyphae amyloid.
        J. Habit pleurotoid.....NEOSESSILES
        J. Habit mycenoid or collybioid (see *Epiphylli*).
A. Lamellae with collarium.
  K. Stipe insititious, central; epicuticular bodies "en brosse," or dendrophysoid; habit mycenoid; stipes sometimes ramified.....ROTULAE
  K. Not combining the characters enumerated above (see "B").

It will be noticed that this key makes no mention of the section *Spinosissimi* Sing. in Sing. & Digilio. This section, with its single known representative, keys out with *Marasmius*, but has no close relative in the genus. The disintegration of the hyphal chains forming the epicuticular spines characteristic of this section suggests genera such as *Mycena*, *Phaeomarasmius*, and *Leucocoprinus*, but the fungus is amply different from any of these in spore characters and the sum of its other macro- and microscopical as well as developmental characters. I propose a new genus for *M. spinosissimus* Sing.

Amparoina Sing., gen. nov. Pileo echinato; hyphis externis ornamenti pilei spinulosis, interstitiis inter spinas dendrophysatis *Favolaschiarum* modo; hyphis basidiolisque vetustis (bulbilliformibus) nec non parietibus externis hypharum epicutis pilei pseudoamyloideis; basidiolis juvenilibus sporisque inamyloideis, levibus, hyalinis; hyphis vestimenti disintegrantibus, cellulis liberis demum numerosis et ex ea re superficie pulveracea; lamellis subliberis, haud collariatis. Ad lignum emortuum.—Nota: An sporulatio praecox atque formatio cellularum bulbilliformium pars diagnosis sit, in genere hucusque monotypico difficile dictu. Species unica submycenoidea formosissima a filia reperta et genus ei dedicatum est.—**A. spinosissima** (Sing.) Sing. comb. nov. (*Marasmius spinosissimus* Sing., Schweiz. Zeitschr. Pilzk. **28**(11): 193. 1950), TYPUS.

INSTITUTO LILLO
TUCUMAN, ARGENTINA

THE FUNCTIONS OF THE MICROSPORES OF GELASINOSPORA CALOSPORA VAR. AUTOSTEIRA [1]

BERNARD J. SLOAN [2] AND G. B. WILSON

(WITH 3 FIGURES)

Gelasinospora calospora (Mouton) Moreau & Moreau variety *autosteira* (Alexopoulos & Sun) Alexopoulous & Sun (**1954**) is a heterothallic ascomycete originally described as a new species, *G. autosteira* by Alexopoulos and Sun (**1950**). Tylutki (**1955**) described this variety as "hermaphroditic" inasmuch as single ascospore strains usually produce both protoperithecia and spermatium-like bodies (hereinafter referred to as microspores). However, Tylutki's study also brought forth a number of isolates which did not produce protoperithecia. Inasmuch as mating between compatible strains appeared to depend on the ability of one strain to produce protoperithecia and of the other to produce microspores, it appeared likely that both structures played primary roles in the fertilization process.

The present work was undertaken in order to establish the function of the microspores. These bodies, borne on branched microsporophores, measure about 2.5 μ in diameter. The ability of a given strain to develop microspores is probably genetically controlled (Tylutki **1955**) but environmental conditions appear to be of considerable importance as well. Neither the genetic nor the environmental factors responsible for the microspore production have yet been worked out satisfactorily.

By analogy with the closely related *Neurospora*, the microspores of *G. calospora* var. *autosteira* might well be expected to function both as spermatia and microconidia. The following tests of these two possibilities were therefore carried out:

[1] This represents a portion of the research presented by the senior author in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Michigan State University. The writers are indebted to Dr. C. J. Alexopoulos, Professor and Head of the Botany Department of the State University of Iowa, under whose supervision this study was initiated, for his interest and helpful suggestions and for reading the revised manuscript.

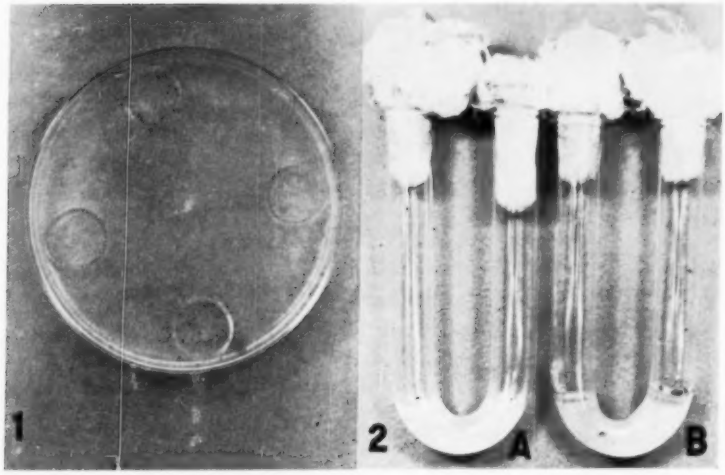
[2] Present address: Microbiological Research Section, Biochemical Research and Development Department, Chas. Pfizer and Co., Inc., 630 Flushing Avenue, Brooklyn 6, New York.

MICROSPORES AS SPERMATIA

a. Single ascospore strains known to be capable of producing microspores were grown on corn meal agar slants. When microspores developed in reasonable numbers, sterile distilled water was poured into the tubes which were shaken to dislodge the microspores. Suspensions thus obtained were filtered under sterile conditions through cotton filters of such porosity as to allow microspores to pass but to exclude mycelial fragments of visable size. Such filtrates were examined microscopically for mycelium and samples were plated on corn meal agar plates under conditions suitable for growth. In no case did we find mycelium by microscopic examination or obtain growth on inoculated plates. As a test of the spermatizing power of the filtered microspore suspensions, plates were inoculated with strains of the opposite mating type. When the mycelium had matured sufficiently so that protoperithecia had developed, sterile glass rings were placed over clusters of protoperithecia. In half of the rings we placed enough of the microspore suspension to guarantee the addition of 80,000 to 120,000 microspores and within the other half we placed an equivalent volume of sterile distilled water. This experiment was repeated thirteen times. In every case perithecia matured and produced normal ascospores where the microspores had been added and nowhere else (FIG. 1).

b. One arm of a U-tube in which the U was completely filled with corn meal agar was inoculated with a protoperithecial strain of suitable mating type. Mycelial growth was allowed to take place until hyphae appeared on the agar surface in the other arm. When protoperithecia had developed on the surface of the agar in both arms, one side was treated with microspore suspension and the other with sterile distilled water. Where the microspores were sown, perithecia with mature ascospores developed; no perithecia developed where the distilled water was added (FIG. 2, B). This experiment was also repeated a number of times with the same results.

In another series of U-tube experiments, one arm of each of several U-tubes was inoculated with mycelium of a protoperithecial strain, and the other arm with a suspension of microspores of a compatible strain. Hyphae originating from the arm of the U-tubes inoculated with the protoperithecial strain grew down and around the bend of the tubes and formed a mycelial mat among the microspores. Eventually protoperithecia appeared and developed into mature perithecia containing typical ascospores. Protoperithecia in the opposite arms of the U-tubes where no compatible microspores were present did not develop further.



FIGS. 1, 2. Spermatization experiments. 1. Perithecia produced in rings resulting from the spermatization of protoperithecia of one mating type with a suspension of microspores of the opposite mating type. 2, A. One of the 43 U-tubes inoculated with cross-compatible strains. No perithecia were produced at the surfaces in either arm of these U-tubes. In one tube, a few perithecia developed at the junction of the two strains. 2, B. One of several U-tubes, one arm of which was inoculated with a protoperithecial strain of suitable mating type. When protoperithecia had developed on the agar surfaces in both arms, one side was treated with microspore suspension and the other with sterile distilled water. Mature perithecia developed only in those arms where the microspore suspension was added.

These experiments indicate that microspores can indeed effect "fertilization." Furthermore, the U-tube experiments suggest that nuclei from microspores usually do not migrate through the hyphae of the compatible strain.

The question of the exact mechanism through which plasmogamy takes place is less easily resolved. However, the following findings are at least suggestive:

1. In 43 U-tubes, opposite arms were inoculated with cross compatible strains. Mycelia from both strains met and intermingled at the base of the U. In no tube did protoperithecia develop into perithecia at the surface in either arm (FIG. 2, A). In one tube a few perithecia developed at the juncture of the two strains. These experimental results certainly do not fit expectations on the hypothesis of hyphal fusion followed by nuclear migration. The exceptional case of perithecia at

the juncture does represent the possibility of direct fertilization of a protoperithecium by a hyphal tip.

2. If hyphal fusion followed by nuclear migration occurs, at least some of the hyphal tips taken from the vicinity of developing perithecia or from recently intermingled hyphae in "mated" cultures should be heterokaryotic for mating type. Some 212 such subcultures were prepared including many from the base of perithecia. Of these not a single culture ever developed perithecia.

3. If fertilization is effected by a microspore-trichogyne mechanism, then in order to have a reasonable chance of fertilization some minimal number of microspores must land in the vicinity of the protoperithecium. In order to test this, a version of the glass ring experiment referred to earlier was used. In this case fertilization was attempted by using various dilutions of the microspore suspension placed on the protoperithecia within the rings. Dilutions containing fewer than 100,000 microspores were rarely effective. This experiment was done twice with four replications in the first and six in the second trial.

The evidence to date, therefore, is definitely against the notion of hyphal fusion as a fertilization mechanism in this fungus and strongly favors the idea of a microspore-trichogyne mechanism with the possibility of a hypha-trichogyne mechanism as an additional mode.

MICROSPORES AS MICROCONIDIA

Since microspores were sown on corn meal agar plates dozens of times during the course of this study without once developing fungal colonies, it did not seem very likely that they could germinate as microconidia. However, microscopic examination of suspensions did show that some microspores swelled to several times their diameter and many developed "germ" tubes, sometimes of considerable length (FIG. 3). Also microspore suspensions in sterile distilled water especially when kept at room temperature occasionally developed growth which was presumed to be *Gelasinospora* mycelium.

These general observations suggested that germination might occur in liquid medium. Accordingly flasks containing corn meal broth were inoculated with microspores derived from cotton-filtered suspensions which were (a) tested for power to spermatize a compatible strain, (b) checked microscopically for mycelial fragments and (c) plated on agar plates. Most of the flasks were placed on a shaker and some were kept on the laboratory shelf. In almost all cases mycelium developed in due course (36–72 hours). Random samples of these mycelia were checked

FIG. 3. A single germinating microspore. The microspore wall still remains attached to the long germ tube. ca. × 1000.

by suitable matings and found to be *G. calospora* var. *autosteira* of the appropriate mating type. Growth was initiated in all flasks at one to several points which suggests that only a very small fraction of the microspores germinated. This low frequency also agrees with the microscopic finding that only a very low percentage of microspores showed incipient germination in hanging drops.

Many transfers of germinated microspores from hanging drops to both solid and liquid media were made but in no case did growth continue. These findings indicate that the microspores can act as microconidia especially in liquid media, but under conditions tried to date they do not germinate readily or in large numbers.

CONCLUSIONS

The work reported herein shows quite definitely that the microspores of *G. calospora* var. *autosteira* do act both as spermatia and micro-

conidia. It also indicates that transfer of nuclei by fusion of somatic hyphae is highly improbable. The most probable normal method of fertilization appears to be a microspore-trichogyne mechanism but the possibility of hypha-trichogyne fusion has not been eliminated.

Obviously details of both fertilization and germination have yet to be worked out but the general picture appears to be very clear.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY
MICHIGAN STATE UNIVERSITY
EAST LANSING, MICHIGAN

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A NEW SPECIES OF TEICHOSPORELLA

JOHN B. ROUTIEN

The genus *Teichospora* was erected by Fuckel (**3**) and Saccardo's first treatment (**11**) of *Teichospora* was to place the species described in three subdivisions: *Eu-Teichospora* with perithecia not collapsing and spores colored; *Strickeria* with perithecia finally collapsed-concave and spores colored; and *Teichosporella* with perithecia not collapsing and spores subhyaline.

In 1895 Saccardo (**12**) established the genus *Teichosporella* and transferred to it those species formerly in the subdivision *Teichosporella*. Descriptions of fifteen species of this genus were given by him. Ellis and Everhart (**2**) meanwhile had transferred *Sphaeria inflata* Ell. to *Teichospora* in the subdivision *Teichosporella*.

The writer has found descriptions of the following species of *Teichosporella* added to the literature subsequent to Saccardo's last entry (**12**) for this genus: *Teichosporella subrostrata* Teng (**13**), *T. crebriseptata* Höhn. (**4**), *T. oryzae* Batista & Gayao (**1**) and *T. pachyasca* Luc (**5**).

In a program of examining soil samples for fungi Warcup's (**14**) method and medium were used. A fungus identified as a *Teichosporella* was isolated from two soil samples collected near Bu Kaya, Belgian Congo, in March 1956. It was isolated to PDA and maintained on that medium at 28° C for further study. The culture number of the isolate discussed here was 20M444.

The ascocarps of the fungus form readily on potato-dextrose agar. Old, dried specimens that developed either on artificial media or on sterilized pieces of straw would finally collapse; this trait would seem to eliminate *Teichosporella* as the genus for this organism. However, the ascospores always remained colorless; this would place it in this genus.

Descriptions of species of both *Teichospora* (Saccardo's original sense) and *Teichosporella* were compared with the description of culture 20M444. The fungus was most closely related to *T. oryzae*. Specimens of this species could not be located for comparison, but the main differences between this species and the present fungus are summarized in TABLE I.

TABLE 1

COMPARISON OF *Teichosporella oryzae* (DATA FROM BATISTA & GAYAO (1) FROM SPECIMENS DEVELOPING ON RICE) AND *T. africae* (SPECIMENS ON PDA OR STRAW)

	T. oryzae	*T. africae*
Ascocarp	121.6–136.8 × 114–129.2 μ, brownish	200–300 × 135–235 μ, black
Asci	57–68.4 × 22.8–34.2 μ, clavate, paraphysate, sessile (or short pedicellate in text of paper)	90–100 × 40–48 μ, oval to clavate or elongate, with pseudoparaphyses, with a short stalk
Ascospores	22.8–26.6 × 8.3–10.6 μ	35–40 × 14–15 μ

The differences between this fungus and heretofore described species were so great that the fungus was considered to be a new species for which the name *Teichosporella africae* is proposed.

Teichosporella africae sp. nov.

Ascocarpia ovata, late conica vel elongata, ostiolata, atra, saepe collapsa. Asci ovati vel clavato-elliptici, breviter stipitati, 90–100 × 40–48 μ, octospori. Ascosporae elongato-ellipsoideae, hyalinae, muriformes, 35–40 × 14–15 μ, ad septa constrictae.

Growing moderately fast on potato-dextrose agar at 28° C; mycelium black. Ascocarp ovate, broadly conical or elongated, wider at base or middle, ostiolate, black except for lighter colored apex; old, dried specimens often collapsing. Pseudoparaphyses present. Asci oval, clavate to elliptical with a short stalk, 90–100 × 40–48 μ, 8-spored, bitunicate, in a layer at base of fruiting body; wall 5–11 μ thick at apex but much thinner at base. Ascospores elongate-ellipsoidal, hyaline, never becoming dark, muriform with 4–5 cross-walls and 2–3 longitudinal septa in the central, larger cells, 35–40 × 14–15 μ, constricted at septa, irregularly arranged in asci.

Type specimen is deposited in the Cryptogamic Herbarium of the New York Botanical Garden.

A fruiting-body arises from one of a linear group of swollen cells of a hypha. The early stages resemble the figures given for *Pseudoplea Gaeumannii* (**9**, **15**) and *Muellerella nigra* (**10**). At an early stage of development the young ascocarp has a short stalk attaching it to the hypha. When about half-grown a trichogyne-like structure frequently develops near the apex, but no evidence was seen that it had any function.

Sectioned and stained material was not available, so the ascocarp tissue was examined by crushing the ascocarps or gently tearing them apart. When this was done it was found that in very young specimens

containing newly formed asci there was a mass of tissue of very narrow, fragile, hyaline hyphae apparently attached near the top of the ascocarp and separating the asci. This was considered to consist of pseudoparaphyses like those found in various fungi with bitunicate asci rather than to be pseudoparenchyma. It did not disintegrate later.

Discharge of ascospores in water mounts was not frequently seen. On one occasion eight discharged spores were found in one group. At another time, four were seen being discharged in such rapid succession as to be ejected almost in a group. Sometimes the tip of an ascus could be seen projecting from the ostiole of an ascocarp that had developed on straw. When the inner wall of a test-tube culture of the fungus was examined isolated single ascospores were found. The bitunicate nature of the ascus wall was clearly seen several times when the outer wall broke and the endoascus protruded.

Miller (**7**) pointed out that "There is a common Phaeodictyae group of closely related species now in *Cucurbitaria, Fenestella, Pleospora, Teichospora, Pyrenophora* and *Pleosphaeria,* which have asci embedded in paraphysoids as well as muriform spores, and so belong in the Pseudosphaeriales." The new species discussed here and those species of *Teichospora* examined by Munk (**8**) should be placed, therefore, in the order Pseudosphaeriales or the Pleosporales of Luttrell (**6**).

MICROBIOLOGICAL RESEARCH SECTION
BIOCHEMICAL RESEARCH & DEVELOPMENT
CHAS. PFIZER & CO., INC.
630 FLUSHING AVE.
BROOKLYN 6, N. Y.

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SOME SPECIES OF THE GENUS TRICHOPHAEA [1]

BESSIE B. KANOUSE

(WITH 7 FIGURES)

Boudier (**1885**), in working toward a clarification of the taxonomy of the Discomycetes, established many new genera. His later works (**1907**, **1905–1910**) further emphasized his revised classification. His system has not been accepted generally in its entirety because it has been claimed that it represented an artificial arrangement of the species. The genus *Trichophaea* Boud. comprises a concise taxonomic unit within the heterogeneous "*Lachnea*" complex, characterized in part by having small, fleshy, flat apothecia, white hymenium and brown hairs arising from excipular cells. Boudier (**1907**) transferred 18 species to the genus. Grélet (**1917**) added *T. boudieri*, and Le Gal (**1937**) named *T. gregaria* var. *intermedia*. Recently (**1955**) Le Gal made the new combination *T. crinacea* (Schw.) Le Gal from *Peziza crinaceus* Schw., a species described from a collection made in the United States. I have not seen collections from Brazil and Madagascar which she identified as *T. crinacea*, but it would appear from her discussion that she has misinterpreted Schweinitz's species. I believe that the species belongs in the genus *Scutellinia*. With the permission of Dr. W. C. Denison I refer to Publication 20.015 from the Cornell University Microfilms; Studies in the Genus *Scutellinia*, in which Dr. Denison treats *P. crinaceus* as belonging to *Scutellinia*.

In **1942** Le Gal reported briefly on the spore ornamentation in *T. paludosa* Boud. In **1947** she published her valuable treatise Recherches sur les ornamentations sporales des Discomycètes operculés. Among the species she discussed were *T. paludosa* and, briefly, *T. pseudogregaria* (Rick) Boud. She presented a classification which in many respects followed Boudier, but which incorporates important modifications with respect both to taxonomy and phylogeny. Some of these views were included in a presentation before the Stockholm Congress in 1950 (pub. **1953**) and again in her treatment (**1955**) of the Discomycetes of Madagascar. Seaver (**1928**) placed *Trichophaea* in syn-

[1] Papers from the University Herbarium, The University of Michigan.

onymy with *Patella*. In addition to the species transferred by him to *Patella*, he described *P. tuberculata*, which I regard as belonging to *Trichophaea*. Dr. R. P. Korf (1954 ined.) signified his recognition and approval of the genus *Trichophaea* through his distribution of *T. abundans* (Karst.) Boud., No. 15 in his Discomyceteae Exsiccatae.

The purpose of this paper is to present the genus *Trichophaea* as an acceptable genus, to record some species known from the United States, and to present some comparative morphological studies of these species, with particular reference to characteristics of the excipular cells and hairs. It does not purport to include a complete survey of the species for the United States. Two new species are described (*michiganensis* and *bullata*) and *Patella tuberculata* Seaver is transferred to the genus.

In the course of this study generous help was received from Dr. R. P. Korf, particularly in connection with *T. bicuspis* Boud., I extend sincere thanks for his courtesy in offering the loan of both collections and notes. To Dr. Donald P. Rogers I also express my appreciation for the opportunity of examining numerous collections of several species from the herbarium of the New York Botanical Garden. Dr. C. E. Smith kindly allowed me to examine the type collection of *Peziza erinaceus* Schw. from the Herbarium of the Academy of Natural Sciences of Philadelphia. Through the permission of Dr. G. Taylor, Director of the Royal Botanic Gardens, Kew, England, Dr. R. W. G. Dennis made studies on the type collection of *Peziza woolhopeia* Cke. & Phill. and supplied information concerning that species. My thanks go to them for their cooperation.

DISCUSSION

From comparative morphological studies on the species reported in this paper, it became evident that some characters of the exciple have not received sufficient emphasis in the literature to point up their true diagnostic value. From the consistency with which certain characters are maintained within a species, it is believed that they can and should be used as dependable diagnostic characters. A few details are also given concerning the use of iodine solution and 2½% KOH as reagents.

MORPHOLOGY OF THE EXCIPLE

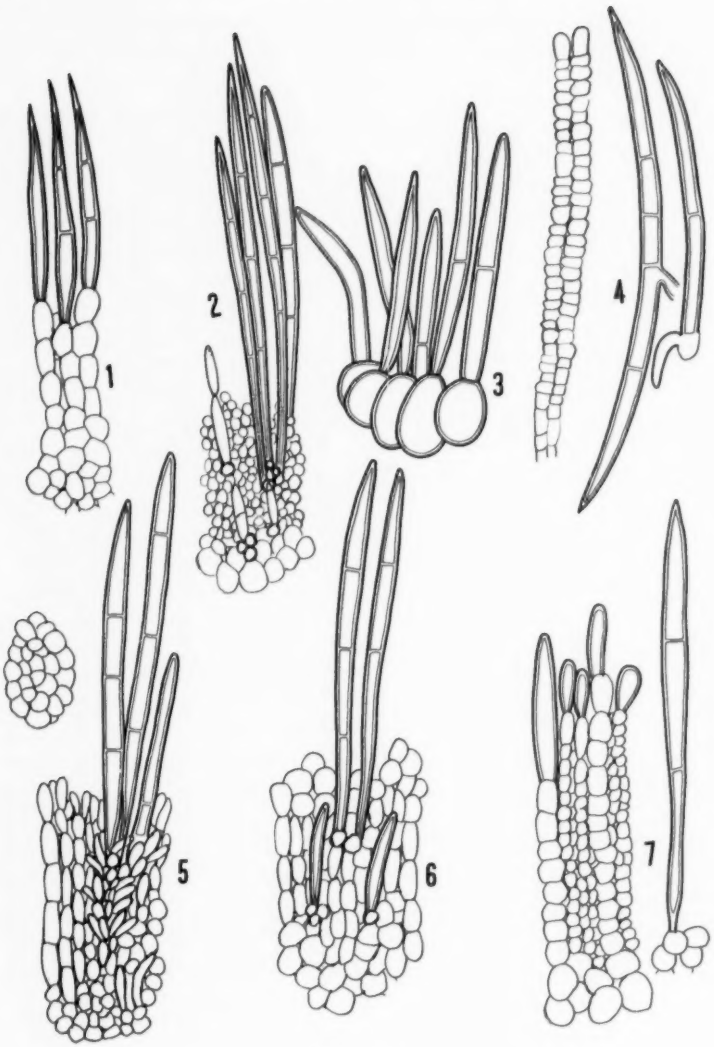
The exciple is the tissue adjoining the hypothecium and forming the outermost covering of the apothecium. With the use of an oil-immersion objective and sufficiently thin sections, these cells can be studied with astonishing accuracy.

The simplest excipular formation is that in which the cells are relatively uniform in size and shape throughout the tissue. Such a condition reaches its fullest expression known for the genus in *T. bicuspis* Boud. In this species the entire outer layer is composed of small block-like cells arranged in parallel rows, beginning at the base of the apothecium and extending to the margin of the cup (FIG. 4). They appear not unlike the kernels on a dry ear of corn or like bricks piled in regular fashion in a wall. A count of several such rows showed an approximation of 60 cells in a single row. It is a striking and unusual formation and, I believe, has never been reported elsewhere for the genus.

Variations of this parallel arrangement of rows of cells are found in other species, but never does it reach such precision as in *T. bicuspis*. In *T. abundans* (Karst.) Boud. (FIG. 1) the uppermost portion of the exciple is composed of parallel rows of cells but the individual cells are less uniform in shape. They are large, subglobose and the chains are shorter. In *T. michiganensis*, in which chains of cells are present in the upper part of the exciple, there are rows of small cells, and interspersed among them are rows of much larger cells (FIG. 7). In *T. amphidoxa* (Rehm) Boud. the exciple seems to be nearly undifferentiated. The dense mat of hairs makes it difficult to study the cellular formation satisfactorily. In *T. tuberculata* (FIG. 5) the excipular cells for a short distance below the margin tend to be long, narrow and thick-walled, and dark colored. Overlaid or incorporated in the primary excipular tissue are fan-like strands of very dark brown-walled cells that, with the accompanying hairs, have a braided appearance. These fans reach to the margin and make shallow scallops which produce an uneven margin. In *T. paludosa* Boud. the marginal cells that are not in the dark fan-like strands tend to be larger and more or less subglobose. In *T. bullata* an area of dark brown heavy-walled cells is found at the base of the apothecium, while the upper portion is composed of large pale brown cells more nearly polyhedral in shape. Piles of marginal cells are also found in *T. pseudogregaria* (Rick) Boud. and in *T. gregaria* (Rehm) Boud. In the former the irregular scallops thus formed are more conspicuous than in *T. gregaria* in which species the cells forming the scallops are smaller.

The presence of dark-colored cells either occurring singly or in small patches is common in many species. When present it is from such cells or groups of cells that the hairs arise. If hairs arise from groups of such cells, then a fasciculate condition obtains.

The color of the outside of the apothecia is some shade of brown. This color may be in the walls of a portion of the exciple or in all of



FIGS. 1–7.

FIGS. 1–7. 1. *Trichophaca abundans*, showing marginal hairs and origins in apical cells of short chains in the exciple. 2. *T. gregaria*, hairs of the fringe extending beyond the margin and their origins in small cells in the exciple. 3. *T. bul-*

the cells, or in the whole or parts of walls of the hairs. It varies from very pale to deep dark brown.

CHARACTERISTICS OF THE EXCIPULAR HAIRS

In the genus *Trichophaea* the excipular hairs have their origin in the excipular tissue. In this respect the genus differs from *Scutellinia*, in which the hairs arise from deep within the hypothecial layer. Le Gal (**1955**) has illustrated this hypothecial connection for *Scutellinia texensis* (B. & C.) Le Gal.

What has been said concerning the constancy of the morphology of the excipular cells is equally true regarding the type of hairs on the exciple and their general position on the apothecia. The pattern is astonishingly precise for a species, and the arrangement differs markedly between species. Such dependable characters, then, should be considered of prime diagnostic importance.

Characterization of the genus prescribes the presence of brown hairs with their origins in the excipular cells. The color is variable not only within individual hairs but also in different kinds of hairs and their location. In *T. bicuspis* Boud. the hairs are uniformly a rich dark brown, but this uniformity is exceptional. In other species the tip of a hair may be pale and the base dark or vice versa.

The shape of the hairs varies from long-fluexuous to long-rigid, short-adpressed, stiff-broad or sword blade-like. The apices are usually sharp-pointed, but many hairs with obtuse apices are present. The attachment to the excipular cells, and the kind of basal cells of the hairs show marked differences. The base may be a short stem-like attenuation or may be variously swollen. Hairs with swollen bases reach the extreme in *T. bullata* (FIG. 3), in which the bases are fusoid-ventricose or truly large and subglobose. They resemble cystidia in certain species of basidiomycetes. In *T. bicuspis* Boud. (FIG. 4), the attachment is by means of a small delicate hyaline cell (or short row of cells) that is very inconspicuous. In *T. amphidoxa* (Rehm) Boud. the hair emerges from the cells as a mere outgrowth with no apparent differentiated base. In many hairs the lower cells widen out so that the thickest portion, consisting of several of the hairs, is near the base. It has already been mentioned that usually the hairs arise from cells,

lata, marginal hairs with the bulbous basal cells. 4. *T. bicuspis*, excipular cells and two bifurcate hairs. 5. *T. tuberculata*, spore and excipular cells near the margin, showing the strand of small cells from which the hairs arise. 6. *T. paludosa*, showing cells near the margin with hairs. 7. *T. michiganensis*, showing chains of small cells with alternate chains of larger cells and one fully developed hair.

perhaps special ones, that are differentiated from other excipular cells by their small size and thick brown walls. These dark cells may be in groups or patches scattered over the excipular surface or they may occur scattered and singly. In *T. tuberculata* (FIG. 5) the patches are more or less like strands with one end ravelled. The broad top reaches nearly, if not quite, to the margin. The fans are spaced around the margin with paler excipular cells in the interstices. Hairs that form the marginal fringe grow from just below the margin. From the cells lower down in the patch many shorter hairs grow and intertwine giving the darkened area an almost braided appearance. If few to many long hairs have their origins in such patches the result is a fascicle. As many as 50 hairs may be grouped in a fascicle and extend beyond the margin, forming a fringe. In *T. gregaria* (Rehm) Boud. the long marginal hairs arise from single dark-walled cells near the margin, while the short hairs are always found lower down adpressed on the outer surface of the apothecia. In *T. abundans* (Karst.) Boud. the marginal fringe springs from the terminal cell of each row of cells.

Two species present types of hairs that are truly unique for the genus. The bifurcate hairs in *T. bicuspis* Boud. (FIG. 4) have been known since the species was described by Boudier (**1896**). The hair and branch, or spur, are so constructed that they give the appearance oftentimes of a single hair having two pointed ends. The branch may be as long as the original growth of the hair. If the branch is inclined at an angle the difference between the two parts is recognizable. The small "elbow" or origin of the hyaline cell by which the hair is attached to its excipular cell is inconspicuous. I have counted the hairs on several apothecia and the number approximates sixty.

Gwynne-Vaughan and Williamson (**1933**) discussed the development of bifurcate hairs of a similar nature found in *Lachnea scutellata* (Fr.) Gill. They stated that the short branches arise "from the middle cells of a sheath, which are apt to be richest in food materials and their energetic growth may distort the hyphae from which they arise, so that the stalk and tip may lie almost parallel." They illustrated several stages of development of bifurcate hairs of *L. scutellata* (Fr.) Gill. Whether or not, as they suggest, the peculiar branching is closely linked with nutrition is but conjecture. Incidentally the bifurcate branching in *T. bicuspis* is the only instance of any description of this feature I have so far found in references to species of *Trichophaea*.

In *T. bullata* (FIG. 3) I found a very striking conformation of marginal hairs having bases that are truly bulbous. These very large conspicuous subglobose or fusoid ventricose cells are piled at random

at the margin of the apothecia. The swollen bases are pale brown in color. The sword-blade extension is stiff, and pale brown to nearly colorless. A septum separates the bulbous base from the elongated part of the hair. Septa are not always present in the blade. The hairs measure 100–150 μ long, and they form a stiff palisade at the margin. This palisade forms the true margin of the apothecia, that is, the hairs do not arise from below the margin as is frequently the case in other species. Nothing like these hairs has been found described in the literature. The so-called bulbous hairs illustrated by Boudier (**1905–1910**) and by Cooke (**1879**) for *T. woolhopeia* (Cke. & Phill.) Boud. and by Grélet (**1917**) for *T. boudieri* Grélet are entirely different from those found in *T. bullata*. In reviewing the original descriptions of more than one hundred species of "Lachnea," I found hairs with bulbous cells mentioned in but five species, none of which is like *T. bullata*.

SOME CHEMICAL REACTIONS

The use of iodine solution and KOH as reagents in the study of fungi is not a new technique. KOH is frequently used to restore the shapes and contours of dry spores and tissues. Merely as a routine study, I examined sections of *T. tuberculata* with these chemicals. In water mounts the spores are large, 30–35 × 22 μ, greenish yellow in color, and covered with large conspicuous hemispherical tubercules. In 2½% KOH the spores rapidly swell nearly to twice their size, 60–80 × 30 μ and become hyaline and smooth. The tubercules were deflated so that their original positions on the periphery of the spores were indicated by faint rings, the diameter of which was approximately twice that of the tubercule viewed before inflation. No rupture was observed in the membrane surrounding the tubercule nor in the wall of the spore immediately beneath the tubercule. The distention is symmetrical in spores floating freely in a mount. If spores are within an ascus they are distorted by the pressure of other swelling spores or by the obstruction of the ascus wall. The ascus wall seems also to be somewhat enlarged by the KOH. It swells irregularly to conform to the enlarged spores within. Spores retain the enlarged size and shape for hours if kept moist. No indication was ever seen of a return to the former condition before the KOH was applied. The reaction is so rapid that unless the observer is watching the slide while the KOH is being added he may miss seeing part of the expansion process. I used only dried material for the observations. Similar reactions were found when KOH was tried on dry specimens of *T. paludosa* Boud. and *T. pseudogregaria* (Rick) Boud. with the exception that in *T. pseudogregaria* the reaction

was not as conspicuous because the tubercules are not as large or as numerous.

Le Gal (**1942–1947**) discussed and beautifully illustrated (**1947**) the formation of the tubercles on the spores of *T. paludosa* and gave comments on *T. pseudogregaria*. Her studies on fresh material give in detail the stages of the development of the tubercules. She reports the use of stains to determine the substance of which the tubercules are formed. She found that the use of Javel water caused the spores of *T. paludosa* and *T. pseudogregaria* to enlarge and become hyaline and smooth as I found to be the case for *T. tuberculata* with 2½% KOH. However, she stated that she never produced the complete obliteration of the tubercules in Javel water. Neither Le Gal nor I was able to see any indication of a break in the membrane surrounding the individual tubercules nor in the spore wall lying immediately beneath the base of the tubercule.

In iodine solution I found that all tuberculate spores showed a pseudoamyloid reaction—turning gold color. The spores show dramatically their beautiful blackberry shape when so stained (FIG. 5).

It may be assumed that the similarity of reactions to these reagents together with certain morphological characters indicates a close phylogenetic relation between *T. tuberculata, T. paludosa,* and *T. pseudogregaria.*

TRICHOPHAEA Boudier, Bull. Soc. Myc. Fr. **1**: 105. 1885.

Apothecia small, fleshy, flat at maturity (moist), hymenium whitish, bluish or grayish white, externally some shade of brown, exciple pseudoparenchymatic, with or without the presence of small polyhedral to subglobose cells arranged in parallel rows, hairs of various types arising from excipular cells, singly or in fascicles, branched or unbranched, apices pointed (or obtuse), usually forming a fringe at the margin; asci cylindrical, operculate or suboperculate, not turning blue in iodine; spores smooth or rough, guttulae usually prominent; paraphyses without pigmentation; terrestrial or lignicolus.

Type species: *Peziza woolhopeia* Cooke & Phillips. This is the only species mentioned by name when the genus was established.

KEY TO SPECIES

1. Apothecia covered with a dense mat of hairs.....*T. amphidoxa* 129
1. Apothecia not as above.....*2*
2. Hairs bifurcate.....*T. bicuspis* 137
2. Hairs not as above.....*3*

3. Marginal hairs arising from large bulbous cells.....*T. bullata* 131
3. Marginal hairs not as above.....4
4. Marginal hairs arising from the tip ends of chains of excipular cells.....*T. abundans* 130
4. Marginal hairs not as above.....5
5. Marginal hairs long, 600 μ, apothecia small.....*T. boudieri* 139
5. Marginal hairs not as above.....6
6. Apothecia small, asci 4-spored.....*T. michiganensis* 138
6. Asci 8-spored.....7
7. Hairs short, adpressed on lower part of exciple.....*T. gregaria* 133
7. Hairs not as above.....8
8. Spores subfusiform with tubercules.....*T. pseudogregaria* 136
8. Spores ovoid-elliptical; tubercules large.....9
9. Spores 28–35 × 20–22 μ.....*T. tuberculata* 134
9. Spores 22–25 × 14–16 μ.....*T. paludosa* 135

TRICHOPHAEA AMPHIDOXA (Rehm) Boud., Hist. Class. Discom. Eu. 60. 1907

Lachnea amphidoxa Rehm, Kryptog.-Flora Deutschl. Oesterr. Schweiz. **1**: 1048. 1895

Apothecia gregarious, sessile, at first spherical, finally flat, 1–3 mm in diameter, fleshy, whitish hymenium, pale brown outside, inrolled partially when dry, covered with a dense mat of pale brown hairs, 100–150 × 15–18 μ; hairs thick-walled, sparingly septate, with pointed apices, arising from undifferentiated excipular cells, all hairs including those at the margin alike, excipular cells pseudoparenchymatic, pale brown; asci cylindrical, 200–220 × 12–15 μ, suboperculate (?), 8-spored, not turning blue in iodine; spores elliptical, 15–18(–20) × 8–10 μ, smooth (inner wall slightly roughened), without guttulae, in one row in the ascus; paraphyses filiform, apices 7–9 μ wide.

Habitat: On wet clay soil in low places frequented by cows.

Material examined: *B. O. Dodge 753*, Algoma, Wis., Aug. 1909 (NY).

This species was described by Rehm, who reported it from Switzerland and from Germany. It is one of the species transferred to *Trichophaea* by Boudier (**1907**). Rehm also identified as *Lachnea amphidoxa* the Dodge collection from Wisconsin. Seaver (**1928**) placed the species in synonymy with *Patella gregaria*. Since the Dodge collection is the only one in the New York Botanical Garden Herbarium it is inferred that Seaver had reference to this particular Wisconsin collection when he made the transfer. However, the fungus is unquestionably a good species, as Rehm reported it, and it is certainly distinct from *T. gregaria*. It unquestionably belongs to *Trichophaea*. It bears little resemblance

to *T. gregaria*. In the latter species the outside is covered with an evenly scattered arrangement of short adpressed hairs over the lower surface and with long fasciculate hairs near the margin. In *T. amphidoxa* the hairs are uniformly short and stout, and form a dense mat over the entire surface including the margin. The spores in *T. gregaria* are subfusiform, while in *T. amphidoxa* they are elliptical. In some of the old apothecia in the Wisconsin collection the hairs seemed to have been broken or rubbed off.

TRICHOPHAEA ABUNDANS (Karst.) Boud., Hist. Class. Discom. Eu. 61. 1907. FIG. 1

Peziza abundans Karst., Not. Faun. Flor. Fenn. **10**: 124. 1869

Lachnea abundans Sacc., Syll. Fung. **8**: 186. 1889

Scutellinia abundans Kuntze, Rev. Gen. Pl. **2**: 869. 1891

Patella abundans Seaver, North American Cup-Fungi Operc. 177. 1928

Apothecia gregarious, sessile, flat at maturity, 1–3 mm in diameter, grayish white, exciple thin, composed of large subglobose to polyhedral thin-walled cells, pale brown cells in margin and immediately below are arranged in parallel rows or chains of cells to a depth of 35 μ, externally covered with hairs; marginal hairs 40–60 × 8 μ, with thin walls, apices sharply pointed, 1–3-septate, dilute brown to hyaline, darker below, arising from the terminal cells of the chains of excipular cells, hairs below the margin long, 120–250 × 6 μ, sparingly septate, flexuous, scattered, pale brown, apices pointed or obtuse, even in width throughout, basal cell undifferentiated or sometimes with a small foot-like cell; hypothecium pseudoparenchymatic; asci cylindrical, 120–150 × 8–10 μ, 8-spored, not turning blue in iodine; spores elliptical, ends narrowed, 14–15 × 6–8 μ, smooth, faintly yellow, containing a refractive central guttula, uniseriate in the ascus with ends overlapping; paraphyses hyaline, filiform, apices slightly clavate, 6–7 μ wide. Conidial state reported from culture.

Habitat: On peat moss on burned soil; on sterilized soil in greenhouse. Conidia known in culture.

Material examined: Korf, Discomyceteae Exsiccatae No. 15 (CUP 37342); *Korf 1468, 1469* (CUP); *Seaver*, Iowa 1904 (NY).

This species represents a case of simple excipular morphology. The cells are nearly uniform in size and shape throughout. There is a strong tendency for the cells in the upper part from the margin downwards to be arranged in chains. It is from the tip cells of the chains that the hairs forming the marginal fringe are formed.

Dodge (**1922**) as *Lachnea abundans*, Gwynn-Vaughan and William-

son (**1927**) as *Lachnea cretea* (Cke.) Phill., and Kevorkian (**1932**) as *Patella abundans* (Karst.) Seaver studied this species in culture. All report a Botrytis-like conidial stage. According to their reports the fungus responds readily to cultural conditions. Kevorkian grew the fungus on many media, on most of which he obtained conidia or apothecia or both. The species is considered to be homothallic.

Trichophaea bullata sp. nov. FIG. 3

Apotheciis gregariis, sessilibus, 3–4 mm latis, applanatis, hymenio albido, pilis marginis brevibus, 100–125 × 15–20 μ, cellula basali exclusa, pallide brunneis vel hyalinis, inferna cella bullata, subglobosa vel fusoideo-ventricosa, 30–35 μ lata, pilis inferis longis septatis, ascis cylindraceis 250–325 × 18–20 μ; ascosporis levibus, hyalinis, paraphysibus, filiformibus, hyalinis.

Apothecia scattered to gregarious, sessile, 3–4 mm in diameter, flat at maturity (moist), fleshy, hymenium whitish, exterior pale brown, dark brown mycelium frequently present at the base of the apothecium, exciple composed of large, subglobose to polyhedral cells, thin-walled, pale brown, cells small near the base of apothecia, clusters of small dark brown cells scattered over the surface; covered with hairs, hairs forming the margin crowded, arising from large conspicuous subglobose or fusoid-ventricose basal cells 30–35 μ or more in diameter, with a septum between the swollen base and the sword-shaped portion, sparingly septate above, often non-septate, apices sharp pointed, pale brown to subhyaline, tinted darker brown at base, 100–125 × 15–20 μ exclusive of basal cell, short hairs present usually with obtuse apices; hairs on lower part of the exciple long, 300 × 6–7 μ, dark brown, thin-walled, many-septate, scattered singly, arising from small dark-colored cells; asci cylindrical, 250–325 × 18–20 μ, thin-walled, lower part usually collapsed in age, 8-spored, not turning blue in iodine; spores broad-elliptical, 20–22 × 12–14 μ, smooth, hyaline, containing one large refractive guttula, pseudoamyloid; paraphyses filiform, hyaline, slightly broadened at the apices, clinging together in bundles.

Habitat: On soil among mosses, on cellar floor, on wet earth and humus.

TYPE collection: *A. H. Smith 1540*, on humus, Silver Lake, Pinckney, Michigan, MICH.

Material examined: *E. B. Mains*, Ann Arbor, Mich., July 30, 1915; *A. H. Smith and E. B. Mains*, Cross Village, Mich., Aug. 21, 1933; *A. H. Smith 1540*, Pinckney, Mich., July 11, 1935 (MICH); Eastport, Me.; *M. Sharp 2082, 2098*, Sept. 28, 1930, Tenn.; *J. R. Kienholtz K123, 60*, Hood River, Oregon, 1932; *P. A. Rydberg and F. K. Vreeland*, Colo., June 30, 1900; Sand Lake, U.S.A. (*C. H. Peck?*) (NY).

The difficulty attending the identification of this fungus brought to light several discrepancies and misconceptions concerning two old species, *Peziza albo-spadicea* Grev. and *Peziza woolhopeia* Cke. & Phill., two of the species transferred by Boudier to *Trichophaea*. The problems arose primarily in connection with the uncertainty about the kind of marginal hairs present in *T. woolhopeia*. The apothecia were described as "beset externally with fascicles of erect sharp pointed hairs which are colorless at the tips." No mention was made of hairs with bulbous bases. However, Cooke (**1879**), one of the co-authorities for the species, published an illustration (Mycographia, Pl. 113, f. 404) showing a peculiar basal tiered formation of cells. Boudier (**1905–1910**), who later gave a redescription of the species, mentioned hairs with bulbous bases but without specifying their location on the apothecia. His accompanying illustration shows a small cluster of hairs with small basal swellings. Neither Cooke nor Boudier showed the condition found in this fungus.

Through the courtesy of Dr. G. Taylor, Director of the Royal Botanical Garden, Kew, Dr. R. W. G. Dennis supplied me with drawings made from a study of the type collection of *Peziza woolhopeia*. No bulbous cells were shown in the sketches he provided, and he stated that "he sees nothing like the curious tier of globose cells at the base of the hairs shown in Cook's Monographia tab. 113, fig. 404." The possibility of our fungus's being *T. woolhopeia* was thus ruled out.

The second species involved was *T. albo-spadicea* (Grev.) Boud. (*Peziza albo-spadicea* Grev.). This species was described as having the "external surface including the margin strigose with reddish brown hairs." The concept of the presence of reddish brown hairs seems always to have been retained for this species, to judge from European and English literature. Phillips (**1887**) stated that the designation "spadicea" was given because of the bay color of the hairs.

From an examination of the collections in the New York Botanical Garden Herbarium labeled *Patella albo-spadicea* (presumably those collections upon which Seaver (**1928**) based his concept of the species), it was found that none of the specimens had the strigose reddish brown hairs at the margin. Instead there were found short, pale brown hairs with the large bulbous cells which are identical with those described for *T. bullata*. On the presence of such hairs the New York Botanical Garden collections could not possibly be referred to *T. albo-spadicea*.

To complicate the situation still further, Seaver (**1928**) placed *T. woolhopeia* in synonymy with *T. albo-spadicea* and incorporated in his

description of *Patella albo-spadicea* the presence of bulbous hairs. This statement was probably derived from the erroneous concept of *P. woolhopeia* which was based, in part at least, upon Cooke's illustration (Mycographia, Pl. 113, f. 404) which he cites under *P. albo-spadicea*.

It must therefore be concluded that the fungus with the conspicuous fusoid-ventricose or subglobose base on the marginal hairs is neither *P. woolhopeia* nor *P. albo-spadicea*.

TRICHOPHAEA GREGARIA (Rehm) Boud., Hist. Class. Discom. Eu. 60. 1907. FIG. 2

Humaria gregaria Rehm, Winter. Flora **35**: 508. 1872

Lachnea gregaria Phill., Brit. Discom. **2**: 4. 1887

Scutellinia gregaria Kuntze, Rev. Gen. Pl. **2**: 869. 1891

Patella gregaria Seaver, North American Cup-Fungi Operc. 176. 1928

Apothecia gregarious, sessile, fleshy, flat at maturity, hymenium whitish to bluish grayish white, 3–4 mm in diameter, drying cup-shaped, excipulum brownish, pale above, lower part composed of large cells irregular in shape, graduating to smaller thick brown-walled cells which at the margin pile up to make irregular-shaped scallops, interspersed over the upper part of the exciple are small bunches of subglobose cells 3–6 μ in diameter, having dark brown walls, all hairs arise from the small dark-colored cells, those hairs forming the marginal fringe arise from cells below the margin, submarginal hairs rigid, in fascicles 20–30, or less, 150–300 × 7–8 μ (some shorter), pale brown at the apices, pointed, sparingly septate, basal cell frequently a short, stem-like attenuation, hairs below the margin area arising singly from small dark-colored cells, very short, stout, 15–45 μ (or longer), adpressed, sparingly septate, hairs and dark cells giving a mottled appearance to the exciple, hypothecium pseudoparenchymatic; asci cylindrical, 150–275 × 12 μ, 8-spored, not turning blue in iodine; spores fusiform 20–22(–24) × 10–12 μ, 1-celled, yellowish, with one large central guttula, often with smaller ones, uniseriate with ends overlapping, smooth at first, becoming finely roughened; paraphyses copious, flexuous, filiform, hyaline, apices abruptly clavate-thickened, 5–6 μ.

Habitat: On soil, rotting wood and decayed leaves.

Material examined: *A. H. Povah 387*, Aug. 4, 1930, Isle Royale, Mich.; *A. H. Smith*, July 2, 1935, Ann Arbor, Mich.; *L. E. Wehmeyer 118 c*, Nova Scotia, July 27, 1931; *B. B. Kanouse*, Wyo., Sept. 5, 1923 (MICH); *F. J. Seaver, P. F. Shope and J. Henderson 303–304*,

Needles, S. Dak., Aug. 8, 1929; *F. J. Seaver and P. F. Shope 131*, Colo., 1929; *C. Commons 2594*, Fornhurst, Del., Oct. 11, 1894; Thümen Mycotheca Universalis No. 2209 (NY); Rehm, Ascomyceten No. 6 (NY).

Rehm (**1896**), Phillips (**1887**) and Seaver (**1928**) described the spores as smooth, becoming minutely rough. Spores such as these were found in the collections of *T. gregaria* studied. Le Gal (**1937**) described *T. gregaria* var. *intermedia* as differing from *T. gregaria* only in having spores slightly rough. She considered the variety intermediate between *T. gregaria* and *T. pseudogregaria*. My inference is that the var. *intermedia* might be simply *T. gregaria* for which the roughened spores are authentic. The roughness on the spores of *T. gregaria* is unlike that found on the spores of *T. pseudogregaria*. In the latter the roughness is tuberculate and disappears in KOH, while the roughness is not tuberculate and does not disappear in *T. gregaria* in this reagent.

The peculiar adpressed hairs are not found in other species in the genus. In European collections examined the hairs appear darker than those seen in the North American material. The fusiform spores with the conspicuous guttula are common to all.

Trichophaea tuberculata (Seaver) comb. nov. FIG. 5

Patella tuberculata Seaver, North American Cup-Fungi Operc. 174. 1928

Apothecia gregarious, sessile, fleshy, hymenium white, 1–2 mm in diameter, exciple composed of large, irregular, thin-walled cells, faintly colored brown, those just below the margin narrowly elongated and arranged in strands which on reaching the margin fan out, with the end cells rounded apically, making a slightly scalloped edge, brown-walled, hairs ariving from these strands single or in clusters, those nearest the margin 200–400 μ long, forming the marginal fringe, thick-walled, red-brown, sparingly septate, apices pointed or obtuse, hairs on lower part of exciple like those above but smaller and shorter, attached by a short attenuated base; asci cylindrical, in age collapsing throughout the long basal portion and becoming indented between the spores, 200–400 × 25 μ, suboperculate, 8-spored, not turning blue in iodine, becoming expanded in 2½% KOH; spores ovoid-elliptical, 28–35 × 20–22 μ (including the tubercules), greenish yellow, covering with large hemispherical tubercules, 1–2-guttulate, end to end in the ascus, pseudoamyloid, becoming smooth, hyaline and greatly expanded in KOH (often reaching twice the original length and width); paraphyses numerous, hyaline, sparingly septate, filiform, slightly enlarged at the spices, branched dichotomously frequently more than once, exceeding the asci.

Habitat: On damp sandy soil among moss, New York Botanical Garden.

Material examined: Type collection of *Patella tubercula* Seaver (NY).

This species is a typical *Trichophaea;* it is near *T. paludosa* but differs principally in the larger spores. A discussion of the reactions in KOH is given elsewhere in this paper.

TRICHOPHAEA PALUDOSA Boud., Hist. Class Discom. Eu. 60. 1907. FIG. 6

Ciliaria (*Trichophaea*) *paludosa* Boud., Bull. Soc. Myc. Fr. **10**: 65. 1894

Lachnea paludosa Sacc., Syll. Fung. **11**: 400. 1895

Patella paludosa Seaver, North American Cup-Fungi Operc. 174. 1928

Apothecia gregarious, sessile, flat at maturity, 1–2 mm in diameter, hymenium whitish, pallid to fuscous outside, exciple in upper part composed of parallel rows of small elongated pale brown cells ending in large brown-walled subglobose cells which form a firm, slightly scalloped margin, exciple in lower part composed of large irregularly shaped pale brown cells, small clusters of small brown-walled cells are scattered over the entire exciple, hairs distributed over the entire surface, arising from small dark-walled cells, hairs near the margin are either single or in fascicles, arising just below but not on the margin, extending beyond, forming a stiff fringe, 100–600 × 15–20 μ, thick-walled, sparingly septate, quite uniformly dark brown, hairs below like those at the top of the apothecia except for smaller size and shorter length, dark brown, septate; asci cylindrical, 250–300 × 14–16 μ, suboperculate, 8-spored, not turning blue in iodine; spores broadly elliptical, 22–25 × 15–17 μ, covered with large prominent hemispherical tubercules, greenish yellow, 1–2-guttulate, pseudoamyloid (gold colored in iodine) expanding to about twice their length and width and becoming hyaline and smooth in 2½% KOH; paraphyses hyaline, filiform, septate, dichotomously branched one or more times in the upper part, apices abruptly clavately thickened, 7–8 μ in diameter.

Habitat: On soil in swampy places.

Material examined: *B. O. Dodge,* Wis., Kryptogammae exsiccatae No. 1448 (as *Lachnea pseudogregaria*) (NY); *E. B. Mains and A. H. Smith 33–528,* Emerson, Michigan, Aug. 25, 1933; Sydow, Mycotheca germanica No. 392 (as *Lachnea pseudogregaria*); Rehm, Ascomyceten Nos. 1268, 1268b (as *Lachnea pseudogregaria*) (MICH).

For an account of the reaction of this species to KOH the reader is referred to a discussion found elsewhere in the paper. The spores are nicely illustrated by Boudier (**1894, 1905–1910**) and by Seaver (**1911**).

TRICHOPHAEA PSEUDOGREGARIA (Rick) Boud., Hist. Class. Discom. Eu. 60. 1907

Lachnea gregaria pseudogregaria Rick, Oesterr. Bot. Zeitsch. **48**: 62. 1898

Lachnea pseudogregaria Rehm, Hedwigia **38**: (243). 1899

Apothecia gregarious, 2–4 mm, flat when moist, cup-shaped when dry, fleshy, hymenium white, excipular cells pale brown, subglobose, patches of small subglobose cells with thick dark brown walls evenly scattered over the exterior, margin formed of an irregular grouping of large thin-walled subglobose cells some of which form a scalloped edge; hairs forming the marginal fringe arising below the margin, 200–400 μ long, somewhat flexuous, light brown, pointed or obtuse at the apices, frequently in groups of six or more, hairs on lower part of the apothecia shorter; asci cylindrical, 150–200 × 12–14 μ, 8-spored, not turning blue in iodine, spores ellipsoid-fusoid, 20–24 × 10–12 μ, covered with medium-sized tubercules which disappear in KOH, spore size enlarged in KOH solution, pseudoamyloid in iodine; one large central guttula present, paraphyses filiform, branched, hyaline, septate, somewhat rigid, 4 μ at the apices.

Habitat: On wet soil and on mossy ground.

Material examined: *A. H. Smith*, July 2, 1935, Ann Arbor, Mich.; *A. H. Smith 45513*, July 30, 1954, Seven Devil's Mountain, Idaho.

This species has the fusiform spores of *T. gregaria*, but the tubercules on the spores and their reaction to KOH and iodine relate the species to *T. paludosa* and *T. tuberculata*. The swelling in KOH is less pronounced in *T. pseudogregaria* since the tubercules are smaller and less conspicuous than in the other two species with tuberculate spores.

It is interesting to note that the two North American collections have fusoid spores with unmistakable tubercules and are clearly *T. pseudogregaria* while the several European exsiccati designated as *Lachnea pseudogregaria* (*T. pseudogregaria*) which were examined prove to be *T. paludosa*. They have the elliptical spores with large tubercules of that species.

TRICHOPHAEA BICUSPIS Boud., Hist. Class. Discom. Eu. 60. 1907. FIG. 4

Ciliaria (*Trichophaea*) *bicuspis* Boud., Bull. Soc. Myc. Fr. **12**: 11. 1896

Lachnea bicuspis Sacc., Syll. Fung. **14**: 757. 1899

Apothecia gregarious, sessile, flat (moist), inrolled when dry, minute, 1–3 mm in diameter, hymenium white, pale brown outside, intensified by the color of dark brown hairs; exciple composed of parallel rows of cubical cells extending from the base of the apothecia to the margin, cells below the margin to a depth of 5 or 6 are subglobose, light brown; hairs sparse, evenly scattered, all of one kind (seta-like), rich dark brown in color, thick-walled, with or without septa, usually branched once, bifurcate, often the mature branch indistinguishable in shape or size from the primary hair, frequently the two grow to appear like one straight or curved hair having two pointed ends, hair and spur 400–600 × 14–18 μ, attachment to exciple by means of a small hyaline cell (or row of 2 or 3 cells) inconspicuous, some hairs extending beyond the margin; asci cylindrical, 200–300 × 16–18 μ, the lower part frequently a long collapsed hypha-like stem, 6–8 μ at the basal end, suboperculate, not turning blue in iodine; spores elliptical, 14–18 × 10–13 μ, smooth, hyaline, non-guttulate, in one row in the upper part of the ascus; paraphyses copious, flexuous, hyaline, branched, 3–4 μ at the apices.

Habitat: On wet aspen leaves, on rotten wood.

Material examined: *A. H. Smith 15486*, Whitemor Lake, Mich., Aug. 16, 1940 (MICH); *C. T. Rogerson and R. C. Schaffer* (*Rogerson 354 b*), Kansas, May 27, 1951; *C. T. Rogerson 3717*, Colo., Aug. 1, 1954; *C. T. Rogerson* (Korf No. 2387), Waldon, Colo., Aug. 18, 1854; *R. P. Korf 717*, Conn., Sept. 9, 1957. (The last three collections, CUP.)

This description was based upon studies made with an oil immersion lens, on Smith No. 15486. The fungus is unique in two of its morphological features—the exciple and the hairs. The exciple with its peculiar construction of parallel rows of cubical cells covering the entire apothecium differs from all other species described for *Trichophaea*. The apothecia are small. Under low magnification a whole cup can be seen at once in side view. Boudier (**1896**, **1905–1910**) and Grélet (**1939**) illustrated the fungus. Boudier did not emphasize sufficiently the peculiar exciple.

The unusual hairs are seta-like. About 60 of them were counted on several apothecia examined. Their size is disproportionate to the

size of the apothecia. The rich brown color makes them conspicuous. Boudier (**1905–1910**) portrayed their branching. The obscure "elbow" or place of attachment to an excipular cell is small and easily overlooked. I have not seen it illustrated or described. As far as I am aware branching is not found elsewhere in the genus. Septa are sparse; occasionally a spur will be nonseptate.

The following comment concerning the type collection was supplied by notes from Dr. R. P. Korf: "Type specimen: Holotype missing from the Boudier Herbarium, Muséum National d'Histoire Naturelle, Paris. The only collection in his herbarium, presumably a paratype, bears a label reading '*Tricharia bicuspis* B, Montm, ad terram, 7 br. 1895?' ". Dr. Korf designates this as the LECTOTYPE.

Trichophaea michiganensis sp. nov FIG. 7

Apotheciis gregariis, sessilibus, applanatis, 0.75–1 mm latis, hymenio albido vel pallido, inferne brunneo, pilis marginis brunneis, brevibus, ascis 4-sporis, I–; ascosporis ellipsoideis, 16–18(–20) × 8–10 μ, levibus, hyalinis; paraphysibus filiformibus septatis, hyalinis, copiosis, superantibus ascos, apicibus incrassatis.

Apothecia gregarious, sessile, thick, soft, minute, 0.75–1 mm in diameter, white, inrolled when dry with the hairs nearly covering the hymenium, small basal region of the exciple composed of subglobose cells, hyaline, medium thick-walled, extending to the margin, the topmost cell rounded, usually extended into an elongated cell 30–40 × 12 μ, intermingled with the rows of medium-sized cells are other rows composed of larger cells, hyaline, also ending in an elongated marginal cell; hairs scattered uniformly, arising from the excipular cells, golden brown throughout, sparsely septate, medium thick-walled, apices pointed, those on the upper part of the apothecia extending beyond the margin, 150–700 × 10–12 μ, basal cell short, brown, attenuated, none arising from marginal cells; hypothecium pseudoparenchymatic; asci cylindrical, 150–200 × 10–12 μ, thin-walled, 4-spored, not turning blue in iodine; spores elliptical, 16–18 × 8–10 μ, smooth, hyaline, without guttulae; paraphyses copious, hyaline, filiform, branched, exceeding the asci.

Habitat: On leaves in a wet leaf mat.

Material examined: *A. H. Smith 22065,* Wolf Bog, Cheboygan County, Michigan, Aug. 8, 1946, TYPE, MICH.

This very small fungus is separated in part from other species by the 4-spored asci. No 8-spored species has been found described of which this might be considered a form.

TRICHOPHAEA BOUDIERI Grélet, Bull. Soc. Myc. Fr. **33**: 94–96, *pl. 7.* 1917

Apothecia sessile, 1–4 mm in diameter, flat at maturity, whitish, exciple pseudoparenchymatic, marginal cells with rounded tips, patches of small dark-walled cells are scattered over the exciple from which the hairs arise, hairs forming the marginal fringe up to 900 μ, sparingly septate, light brown, apices pointed, base attenuated, hairs below the margin shorter, basal cell sometimes enlarged, thick-walled, sharply pointed, dark brown, many-septate, other hairs on the lower part of the apothecium are long-flexuous non-septate (or sparingly septate), with obtuse apices, less frequent than the other types of hairs, mycelium found at or near the base, hypothecium pseudoparenchymatic; asci cylindrical, 200–260 × 16–18 μ, 8-spored, not turning blue in iodine, smooth, filled with protoplasmic contents that usually obscure the guttulae; paraphyses filiform, numerous, hyaline, branched below near the base, apices narrowly clavate, exceeding the asci by 35 μ.

Habitat: On soil.

Material examined: *A. H. Smith 34811*, Sierra Maria Mts., Wyo., July 13, 1954; *V. Potter 4675*, Ithaca, Michigan, June 10, 1948 (MICH).

This species has conspicuous long rigid marginal hairs with attenuated bases and few septa. The shorter stout sword-shaped hairs lower down on the apothecia are many-septate; intermixed with these is a third type of hair, long, narrow, and flexuous. Grélet did not observe spores with guttulae, but I was able to identify them in a few spores in the American collections; the dense spore content usually obscures them. Grélet (**1939**) illustrated the fungus. This seems to be the first report of the species in North America.

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NOTES AND BRIEF ARTICLES

New Species of Psilocybe

Psilocybe collybioides Sing. & Smith sp. nov.

Pileo dilute ochraceo-brunneo, subhygrophano, viscido, a campanulato repando, 13–40 mm lato.—Lamellis pallidis vel albis, confertis vel subconfertis, plus minusve adnatis, aliquanto latis (e. gr. 2.6 mm).—Stipite albo, a basi apicem versus gradatim obscuriore (cinnamomeo), sericeo-fibrilloso-subsquamuloso in juvenilibus, saepe monstrose contorto, farcto dein cavo, 30–70 × 1.5–4.5 mm.—Carne alba vel pallida vel partim cinnamomea, caerulescente; odore farinaceo dein spermatico.—Sporis rarissimis (e. gr. 10 × 6.5 μ); hymenio e pseudoparaphysibus cystidiolisque efformato; epicute pelliculosa; cheilocystidiis ventricosis, apice ampullaceo vel subcapitato instructis, 17.5–23.5 × 8–8.5 μ.—Ad detritum varium praecipue *Alni jurullensis* var. *spachii* sed etiam in fragmentis putrescentibus aliorum di- et monocotyledonum locis semiumbrosis in zona temperata montana, 2200 m altitudinis s. m., Tafí del Valle, prov. Tucumán, Argentina, *R. Singer T 1882* (MICH), TYPUS.—Nota: Cum descriptionibus *Hypholomatis cyanescentis* R. Maire optime congruit sed hoc ad detritum *Cedri* crescit et characteribus minoribus tantum differt; nostra a *Psilocybe cyanescente* Wakefield longe differt.

Psilocybe strictipes Sing. & Smith sp. nov.

Pileo obtuse flavido-brunneo vel olivaceo-brunneo, isabellino (Ridgway), hygrophano, viscido, pellicula separabili intructo, convexo dein plano, 20–40 mm lato.—Lamellis pallidis, dein sepiaceis, adnatis, horizontalibus, angustis, confertis.—Stipite stricto, elongato, appresse pallido-fibrilloso, fibrillis cum strigositate basis caerulescentibus, saepe ad apicem (e velo fracto) zonato.—Carne caerulescente; sapore miti; odore nullo.—Sporis 9–12 × 5.5–6.5 μ, vix compressis; cheilocystidiis 26–37 × 6–11.5 μ; epicute lata fortiter gelatinascente.—Ad ligna detritumque coniferarum, prope Welches, Oregon, USA, *Gruber & Smith 202448* (MICH), TYPUS.

Psilocybe baeocystis Sing. & Smith sp. nov.

Pileo, lamellis stipiteque ut in specie praecedente, sed sporis (8–)10.5–13.3 × 6.3–7 μ et cheilocystidiis 20–30(–36) × 4.2–5.7 μ.—Ad sphagna etc., prope viridarium, Eugene, Ore., USA, Nov. 1, 1945, *F. P. Sipe* (MICH), TYPUS.

Psilocybe candidipes Sing. & Smith sp. nov.

Pileo sordide alutaceo, hygrophano, sicco albido-alutaceo, convexo, centro depresso, 50–55 mm lato.—Lamellis sinuato-adnatis, latiusculis, subconfertis vel subdistantibus.—Stipite albo, basi strigosissimo.—Carne admodum caerulescente, odore farinaceo; sapore astringente.—Sporis 6.7–7 × 3.5–3.8 μ; cheilocystidiis 18–27.5 × 3.8–6 μ, acutis vel subacutis; cystidiolis praesentibus; hyphis epicutis pilei subgelati-

nescentibus.—Fasciculariter caespitoseve ad terram inter folia *Coffeae* et *Ingae* in plantationibus. Huautla, Oaxaca, Mexico, *R. Singer M 1514* (MICH), TYPUS.

Psilocybe aggericola Sing. & Smith sp. nov.

Pileo brunneo, hygrophano, conico, dein campanulato vel convexo, umbonato vel papillato, 20–40 mm lato.—Lamellis confertis vel subconfertis, anguste et sat profunde sinuatis—Stipite flavido ad apicem, ceterum subbrunnescente, demum brunneo vel nigrescente, initio fugaciter fibrilloso.—Carne caerulescente; inodora.—Sporis 6.2–8.2 × 4–5.2 × 3.6–4.5 μ; cheilocystidiis 20–29 × 3.5–8.2 μ; pleurocystidiis praesentibus; epicute vix gelatinescente.—Ad aggeres terreos viarios, Monumento al Indio, Camino a Tafí del Valle, Rio de los Sosas, 900–1000 m altitudinis s. m., prov. Tucumán, Argentina, *R. Singer T-760* (MICH), TYPUS.

Psilocybe muliercula Sing. & Smith sp. nov.

Pileo rufobrunneo, hygrophano, campanulato, dein convexo, umbonato vel subumbonato vel papillato, demum frequenter applanato, 20–35 mm lato.—Lamellis fusco-sepiaceis, subangustis, ascendentibus vel subhorizontalibus, dein horizontalibus, sinuato-adnatis.—Stipite sordide carneo-albido, dein cum pileo subconcolori, praesertim in parte inferiore, levi, subnudo.—Carne odore farinaceo gaudente.—Sporis (6–)7–8(–10) × 4.2–4.8(–5) × 3.9–4.7 μ, vix vel paullum lentiformibus; cheilocystidiis 12–23 × 3–5.5 μ; pleurocystidiis nullis; epicute bene evoluta sed vix manifeste gelatinescente.—Ad terram in silvis persparsis (sub *Pino pseudostrobo*) prope ripas torrentium montanorum, 3000 m altitudinis s. m., Piedras Blancas, Mexico, *R. Singer M 1611* (MICH), TYPUS.

Psilocybe yungensis Sing. & Smith sp. nov.

Pileo castaneo-brunneo, hygrophano, conico, papillato, haud expanso, parvo.—Lamellis confertissimis, angustis, adnatis.—Stipite atrobrunneo, clarobrunneo-fibrilloso, diametro pilei longiore.—Carne caerulescente; odore nullo.—Sporis 4–6.2 (–7.2) × 3.8–5 × 3.3–3.8 μ, compresso-lentiformibus; cheilocystidiis 18–34 × 5–7.3 μ; cystidiolis praesentibus; epicute paulum evoluta, vix gelatinascente.—Ad humum silvestrem lignaque putridissima in Yungis bolivianis gregatim, Cataratas San Juán, Nor-Yungas, La Paz, Bolivia, 2000 m altitudinis s. m., *R. Singer B 648* (MICH), TYPUS.—Exstat. var. **diconica** nob. Magis conica et apice obconice appendiculato pilei insignis est, ibidem collecta, *B. 651* (MICH), TYPUS.

—R. SINGER AND ALEXANDER H. SMITH, Instituto Miguel Lillo and University of Michigan.

A METHOD FOR OBTAINING SOIL-FREE AQUATIC PHYCOMYCETES

In the course of growing certain aquatic Phycomycetes for use in mycology classes, I have until recently followed the customary procedure of using boiled hemp-seed halves in Petri dishes to which soil

samples and sterilized lake water have been added. Although cultures are readily obtainable in this manner, it is often necessary to clear the colonies of soil and other debris before making satisfactory observations. Frequently, if the fungi are not removed to clean water during the first few days of growth, they become so heavily encrusted with soil particles as to be little more than unattractive conglomerations difficult to study. In order to overcome this inconvenience, I have been using a modified Petri dish which makes it possible to obtain soil-free cultures and avoids the necessity of making early transfers to clean water. Since some members of the Saprolegniales, Blastocladiales and other aquatic Phycomycets are commonly studied in introductory mycology (and could profitably be included in biological courses of a more general nature) the method indicated here is suggested as a simple expedient to enable the student or other interested worker easily to secure highly satisfactory material. Routine procedure is followed, except that the hemp-seed halves are firmly attached to glass points (FIG. 1), elevating the bait above the soil surface. Sufficient water is then added to cover the seeds. When colonies begin to appear, they may be observed without

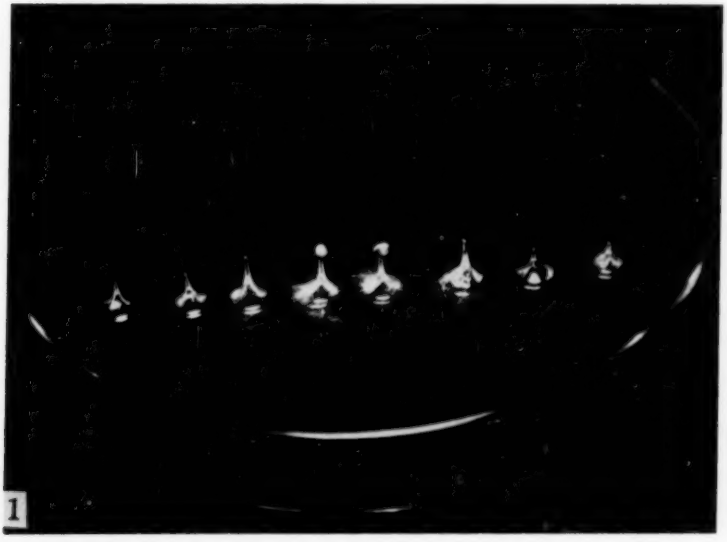


FIG. 1. Glass spikes about 7 mm high, 2 with impaled hemp seed halves.

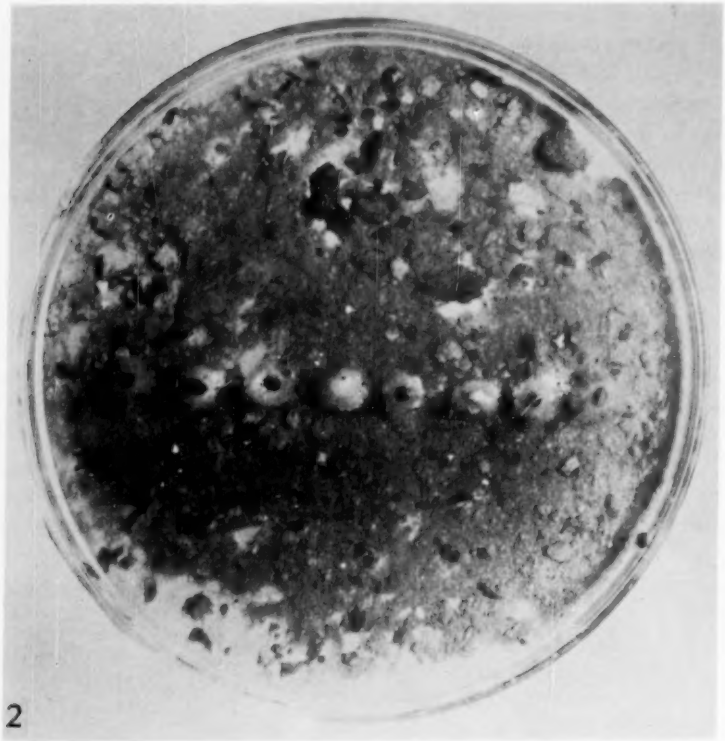


FIG. 2. 7-day-old colonies of aquatic Phycomycetes suspended in water above the soil surface.

removal from the dish (FIG. 2), and examined with either a binocular or compound microscope. The best way found for drawing up spikes from the bottom of a Petri dish was first to heat the dish in an oven to the annealing temperature (about 900° F for pyrex glass), then to pull up the points with a glass rod in any number or pattern desired. This operation was performed by the campus glass blower. In FIGS. 1 and 2, the spikes are about 1.5 cm apart, which allows sufficient separation between the colonies to avoid overlapping after 7 days' growth at room temperature.—B. LOWY, Louisiana State University, Baton Rouge, Louisiana.

VARIATION IN CEPHALIOPHORA TROPICA

Thaxter [1] described *Cephaliophora tropica*, as seen on various dungs, in part as follows: "Sporophores very variable, the heads nearly spherical or more or less elongated, short-stalked or almost sessile." Furthermore, his FIG. 14 illustrated "abnormal development of spores directly from hyphae."

Wolf [2] made no specific mention of variation in the cultures which he isolated from various materials.

Certain variations from the description have been found in two isolates of this fungus grown on PDA slants and are described here. Culture 25M320, isolated from a soil sample from St. James, Barbados, B. W. I., rarely showed the pedicellate sporophore; more commonly the spores were produced on a sessile head, on a spherical, intercalary, uniformly swollen cell or directly on the hyphae.

A strain, QM596, obtained originally from the U. S. Quartermaster Collection, was intermediate between the 25M320 and the description. It had a much larger number and proportion of pedicellate sporophores than did 25M320 but also produced the small, spherical, intercalary cells bearing one or two spores, as well as non-pedicellate swollen heads.—JOHN B. ROUTIEN, Microbiological Research Section, Chas. Pfizer and Co., Inc., 630 Flushing Avenue, Brooklyn 6, New York.

A NEW FISTULINA FROM BRAZIL

Fistulina brasiliensis n. sp.

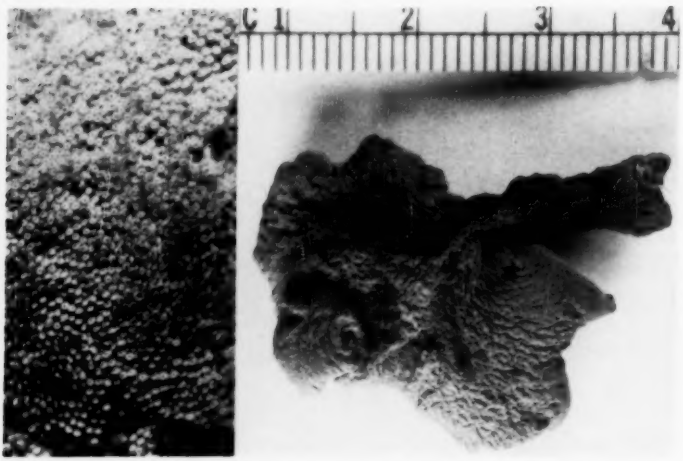
Pileus lobatus, lobis imbricatis, carnoso-coriaceus, 2.5–3 cm latus, 2–2.5 cm longus et 1–5.5 mm crassus, colore ad Maerz & Paul 13E6 (Arizona)–13B6 (Almond Biscuit); stipes lateralis, 1.2–2 cm longus, sursum 3 mm crassus et lateraliter attenuatus. Tubuli isabellini, 400–510 μ longi, 112–190 μ diam. et 63–120 μ luminis diam. Basidia 4.6–5.3 $\times$ 7.5–11 μ. Basidiosporae subglobosae, uniguttulatae, hyalinae, 2.5–3 $\times$ 3.5–4 μ.

Hab.—ad radicem vivum in silvis brasiliensibus (Tijuca, Rio de Janeiro, Distrito Federal, Brasil).

TYPUS—collectus 28 mart. 1957, *O. & K. Fidalgo (OKF 1257)*, in herb. propr.

[1] **Thaxter, R.** 1903. New or peculiar North American Hyphomycetes. III. Bot. Gaz. **35**: 153–160.

[2] **Wolf, F. A.** 1949. Two unusual conidial fungi. Mycologia **41**: 561–564.



Fistulina brasiliensis O. & K. Fidalgo. Left, tubes, × 21; right, basidiocarp, × 2.

auctorum, isotypis in Royal Botanic Garden (Kew), New York Botanical Garden, et National Fungus Collections (71628).

—O. AND K. FIDALGO, National Fungus Collections, Beltsville, Maryland.

HISTOPLASMOSIS

A seminar on "Histoplasmosis" sponsored by the Jewish Hospital Association, Cincinnati 29, Ohio, was held February 11, 1958, in Cincinnati. The invited participants in this seminar are active workers in the field of mycological research. A limited number of mimeographed transcripts of the proceedings will be available on request from Dr. Jan Schwarz of the Association.

REVIEWS

MUSHROOMS RUSSIA AND HISTORY, by Valentina Pavlovna Wasson and R. Gordon Wasson. 2 vol.; XXI + 433 pp.; 82 pl., 28 fig., 3 vignettes, partly colored; 1 chart. Pantheon Books, New York, 1957. $125.00.

The soberest characterization of the Wassons' book that can be offered is that it is the foundation for a new phase of botany—and linguistics, and anthropology—best denominated ethnomycology. The authors have set forth in their volumes what has been learned or can be inferred of the meaning of the larger fungi to diverse peoples; of the origins, relations, and connotations of the common names for mushrooms and their kin; and of the place of mushrooms in ceremony and religion. They have harvested data and suggestions from the museums and countrysides of two continents and from the literature of three; and even to a mycologist instinctively distrustful of the long inferential leaps characteristic of linguistic study, their conclusions seem compelling.

The first generalization, abundantly supported, is that some peoples are traditionally mycophilic, and others almost immovably mycophobic. The northern Slavs furnish the type of the one, and the English of the other: to the mycophile a bolete is buttery; to the mycophobe, slimy. Each disposition is given a chapter of exemplification. There follows a chapter noting the relation of mycophagy and war, and another on mushrooms and murder, real and fictional. Then is developed a series of investigations of such words as toadstool and mushroom, not merely of their etymology (toad stands for poison and the devil, and mushroom is a mucous object) but of their emotional force, and the cluster of ideas to which they belong. The fly amanita is given lengthy and careful study, from which it appears that the prosaic name is a disguise for the ancient association of this mushroom with a variety of demons, and for its use as a ritual inebriant.

The largest section of the work describes the rediscovery of the Mexican rites of the divine mushroom, where in elaborate, indubitably religious ceremonies several species of *Psilocybe, Conocybe, Stropharia,* and *Panaeolus,* regarded and handled as sacred objects, are employed for the purpose of curing ailments, permitting clairvoyance and prog-

nosis, and inducing hallucinations. Several such ceremonials are described in detail; the cult is traced through written records back to A.D. 1450, and to 1000 B.C. by archaeological evidence. Although data from mushrooms in art are used freely in the earlier parts of the work, a special section is later given to this subject. And finally the authors devote a few pages of not entirely flattering attention to "Unscientific Nomenclature."

So much for a glimpse of the substance. The book is written in a prose that is a delight—as scholarly as the studies it describes, and as elegant as the physical form of the volumes. Concerning the form, it is difficult not to run out of superlatives. For comparable letterpress one would look to the Tulasnes' *Selecta fungorum carpologia;* equal beauty of color printing is scarcely to be found even in the magnificent *Icones Farlowianae.* Twenty-six of the colored illustrations are dazzling reproductions of water-colors left by the French naturalist Fabre; many of the black-and-whites are collotype prints of paintings in which there are mushrooms of symbolic significance.

Most mycologists will be troubled by one idiosyncrasy in this work: on principle, generic names are decapitalized. This peculiarity is explained as resulting in a handsomer page of letterpress; the regular capitalization of generic names in the captions is not inconsistent, but *Lophophora Williamsii* (immediately following *rivea corymbosa* on p. 227) and *amanita Caesarea* (p. 365) are harder to understand. And a little more caution in belittling the toxicity of *Amanita muscaria* would make the book safer reading for non-mycologists. One more regret, and one only: that so scholarly and beautiful a work must, on account of its price, be out of reach for many mycologists, and because of the small edition, of most libraries. Those who cannot buy or order the Wassons' book will find a journey to study it time well spent.

Dr. Roger Heim accompanied Mr. R. G. Wasson on one mycological visit to mycophilic southern Mexico, and has grown and studied material collected on others. Readers desiring to pursue the subject of hallucinogenic mushrooms will find his "Notes préliminaires" brought together (with additions) in Rev. de Mycol. **22**. 1957, and a further paper in C. R. Acad. Sci. Paris **245**: 1761–1765. 1957. Mr. Robert Graves has discussed the Wassons' and his own conclusions about mushroom folklore in Saturday Review for May 11, 1957, and Atlantic Monthly for August, 1957. An informative separate article by R. G. Wasson will be found in Life for May 13, 1957, and one by R. G. and V. P. Wasson in Garden Journal N. Y. Bot. Gard. **8**: 1–5, [36²]. 1958. —D. P. R.

G. LINDAU & P. SYDOW—THESAURUS LITERATURAE MYCOLOGICAE ET LICHENOLOGICAE. SUPPLEMENTUM 1911–1930, by R. Ciferri. A–D. II + 689 pp. Renzo Cortina, Via Golgi 14, Pavia. 1957.

Excepting only the *Sylloge fungorum*, no single work on the reference shelves for mycology and phytopathology is as completely indispensable as the Lindau and Sydow *Thesaurus*. The entries in those volumes cover the years through 1910; and although there are other works with partial bibliographies of the later years, none have the completeness and accessibility of the *Thesaurus*. The publication of a twenty-year supplement is therefore an event of considerable importance. As in the *Thesaurus*, phytopathology and the mycopathology of man are indexed in the *Supplementum* along with pure mycology. The relative size of the literature to be covered may be judged from the fact that through 1910 there were listed about 10,700 entries for the letters A–D; for 1911–1930 there are 7167. The *Supplementum* is to be completed with the publication of two or three additional volumes in 1958. The price of the entire work is 20,000 Italian lire (about $32.20).

The volume is legibly printed by offset from well-spaced typed copy, and stoutly bound. It should as a matter of course be procured for those libraries possessing the original *Thesaurus* or the Johnson facsimile. Mycologists owe a debt of gratitude to both compiler and publisher.—D. P. R.

MANUSCRIPT

Publication in MYCOLOGIA is ordinarily restricted to those who have been members in good standing of the Mycological Society of America for over a year immediately preceding submission of manuscript. Exceptions to this regulation require a favorable vote by a majority of the Editorial Board. When a paper has two or more authors, the person submitting the paper is expected to be a member.

Papers should be submitted in duplicate, typewritten and *double-spaced throughout*, to any member of the Editorial Board. When papers are not submitted in proper form, it may be necessary to return them to authors. They will be published in approximate order of their acceptance, except for the address of the retiring President and papers whose cost of publication is paid by the authors, the latter run as excess pagination.

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Brittonia, quarterly; botanical papers; beginning in 1957, official journal of the American Society of Plant Taxonomists. $7.50 a year.

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